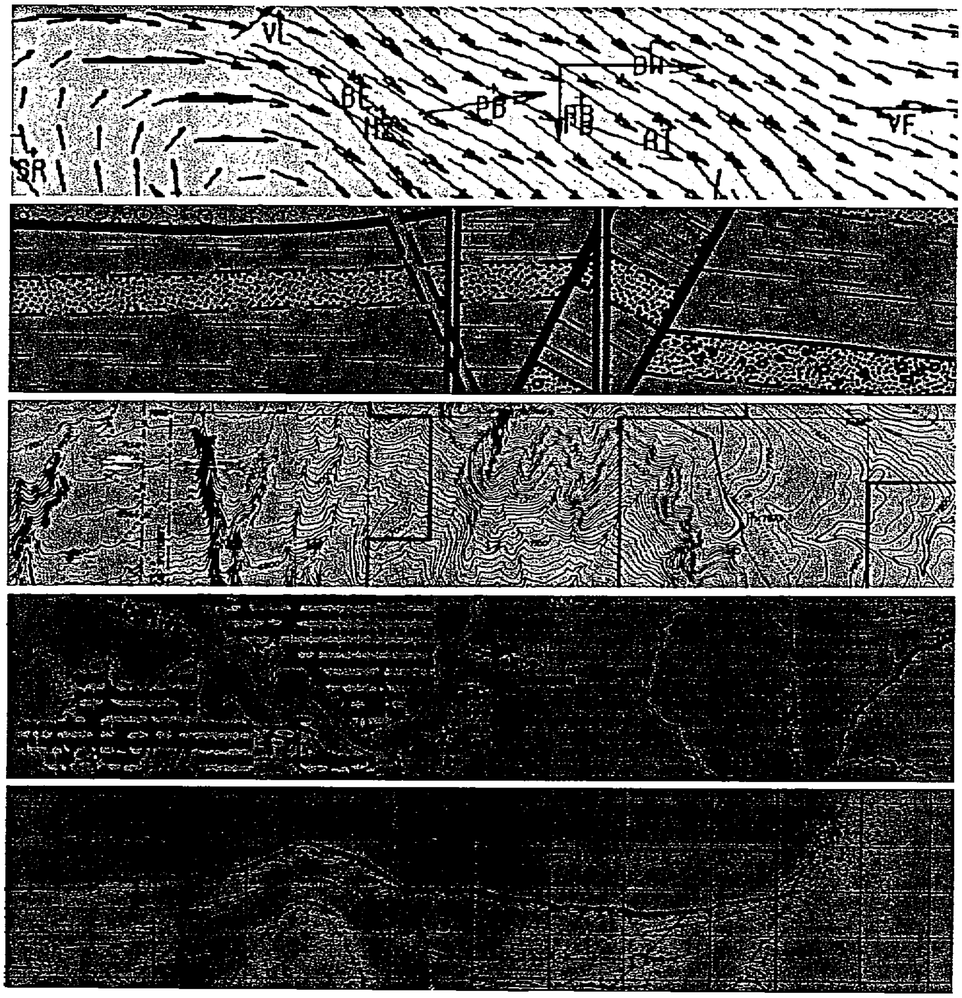


DAMES & MOORE

EFFECTS OF PETROLEUM CONTAMINATED WATERWAYS
ON MIGRATORY BEHAVIOR OF ADULT PINK SALMON
FINAL REPORT
Contract No. 50-ABNC-8-00012 , RU-702
September 1989

Prepared For
National Oceanic and Atmospheric Administration
and Minerals Management Service

DAMES & MOORE

--'Q-J

RU 702

EFFECTS OF PETROLEUM CONTAMINATED WATERWAYS ON MIGRATORY BEHAVIOR OF ADULT PINK SALMON

FINAL REPORT
Contract No. 50-ABNC-8-00012
September 1989

Prepared For

National Oceanic and Atmospheric Administration
Ocean Assessment Division
Anchorage, Alaska

Minerals Management Service
Alaska OCS Region
Anchorage, Alaska

Prepared by

DAMES & MOORE
500 Market Place Tower
2025 1st Avenue
Seattle, Washington 98121

In Association with

Douglas J. Martin,
Clifford J. Whitmus,
and Lon A. Brocklehurst
Pacific Environmental Technologies, Inc.
170 W. Dayton, Suite 201
Edmonds, Washington 98020

Ahmad E. Nevissi
Laboratory of Radiation Ecology
University of Washington
Seattle, Washington 98195

Jeffery M. Cox and Keith Kurrus
Evans-Hamilton, Inc.
731 N. Northlake Way, Suite 201
Seattle, Washington 98103

TABLE OF CONTENTS

Section | Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

Figure

ACKNOWLEDGEMENTS

This investigation would not have been successful without the ideas and efforts of many individuals and organizations. We wish to thank the following Ms. Louisa Rand, Alaska Division of Governmental Coordination, for her assistance and guidance in obtaining the necessary environmental permits for this project; Dr. Clayton McAuliffe for his assistance with the formulation of the hydrocarbon cocktail; Mr. David Erikson, Dames & Moore, for his assistance in the field operations; Mr. Ray McClain and graduate students of the University of Washington for assistance in the field and for the hydrocarbon analysis; Ms. Sandy Brocklehurst for her assistance in the field and for making a video record of the field operations; Mr. David Reitz, Real Time Control Corporation, for assisting in development of an algorithm to compute fish position; and, Mr. Bob Radek and Ms. Elaine Wedell, Dames & Moore, for technical illustration and word processing services. We are especially grateful to Dr. Jim Payne, Scientific Application International Corporation, for his generous assistance in evaluating the effects of an accidental oil spill in the project area. Special thanks also goes to Mr. Lyman Thorsteinson, NOAA Contract Officer Technical Representative, for his assistance during all phases of the study and Mr. Russel Gaegel, NOAA Kasitsna Bay Station, for providing logistic support and assistance in the field.

This study was funded in part by the Minerals Management Service, Department of the Interior, through an interagency agreement with the National Oceanic and Atmospheric Administration, Department of Commerce, as part of the Alaska Outer Continental Shelf Environmental Assessment Program.

TECHNICAL SUMMARY

STUDY TITLE: Effects Of Petroleum Contaminated Waterways On Spawning Migration Of Pacific Salmon - Phase II, Field Studies

REPORT TITLE: Effects Of Petroleum Contaminated Waterways On Migratory Behavior Of Adult Pink Salmon

RESEARCH UNIT NUMBER AND CONTRACT NUMBER: RU702, 50ABNC800012

SPONSORING OCS REGION: Alaska

APPLICABLE PLANNING AREA: Non-Site Specific

COMPLETION DATE OF REPORT: September 1989

COST : $314,286

PROJECT MANAGER: NOAA, OAD/OMA/NOS, Alaska Office, Outer Continental Shelf Environmental Assessment Program (OCSEAP)

AFFILIATION: National Oceanic and Atmospheric Administration

ADDRESS: 701 "C" Street, Box 56, Anchorage, AK 99513

PRINCIPAL INVESTIGATOR: Douglas J. Martin, Dames & Moore (currently with) Pacific Environmental Technologies, Inc.

KEY WORDS: Migratory behavior, salmon, oil pollution, olfaction, avoidance, disorientation

BACKGROUND: The North Aleutian Basin has the most valuable concentration of salmon in North America. All five species of Pacific salmon (sockeye, pink, chum, coho, and chinook) pass through this region to their home streams for spawning. Fishery management agencies are concerned that oil and gas development could have significant impacts on salmon. An issue of particular concern is that an accidental oil spill in the path of migrating salmon may disrupt their spawning migration. Salmon migration behavior during exposure to oil in coastal or open ocean water has never been investigated.

In 1986, the National Oceanic and Atmospheric Administration (NOAA) and the Minerals Management Service (MMS) initiated a two-phased project to investigate the effects of petroleum contaminated waters on the migratory behavior of Pacific salmon. Phase I consisted of laboratory studies to determine the chemosensory detection threshold for oil by adult salmon and the effects of oil on salmon chemosensory function. Phase II, this study, consisted of field experiments to determine if the migration of adult salmon would be disrupted by exposure to oil contaminated waters at concentrations near or above the chemosensory detection threshold.

OBJECTIVES: The purpose of this investigation was to determine if exposure to oil contaminated waters would disrupt the migration of adult pacific salmon. Specific questions that were addressed include:

- Will migrating adult salmon avoid oil contaminated waters at concentrations near or above the chemosensory detection threshold (i.e., $>10^{-7}$ ppb)?
- If adult salmon encounter WSF concentrations above 1.0 ppb, will they become disoriented?
- If adult salmon avoid or become disoriented by oil contaminated waters, does either response disrupt migration to the home stream?

DESCRIPTION: The behavior of adult salmon exposed to oil-contaminated waters was studied by tracking pink salmon movements during periods with and without oil contamination as they migrated through Jakolof Bay, located near Seldovia, Alaska (see area map). Ultrasonic transmitters were attached to adult salmon, which were captured at the mouth of Jakolof Creek. During ebb tide, groups of 10 to 20 tagged salmon were released from a holding pen located 2 km from Jakolof Creek and their movements were tracked by a fixed array of hydrophores as the fish returned to their home stream. Horizontal and vertical movement patterns, swimming speed, and duration-of-return to the home stream were examined in order to identify behavioral responses to oil exposure.

A solution of aromatic hydrocarbons similar in composition to the WSF of Prudhoe Bay crude oil was injected into the water column from a diffuser located midway between the fish holding pen and the mouth of Jakolof Creek. The diffuser was designed to create a vertically mixed hydrocarbon plume. Salmon were released from the holding pen when the hydrocarbon plume had extended approximately 300 m downstream. This enabled the salmon to either move into or around the plume. Hydrocarbon dispersion rate and concentration within the plume were estimated from a two-dimensional vertically integrated hydrodynamic model in combination with a water quality model. The salmon tracking experiments were conducted during late July during the pink salmon spawning migration. Three control experiments and three treatment experiments were conducted on an alternating schedule during the period from July 19 to July 29.

SIGNIFICANT CONCLUSIONS:

- Migrating adult pink salmon do not appear to avoid aromatic hydrocarbon concentrations above the chemosensory detection threshold.
- Salmon do not appear to avoid oil contaminated waters with hydrocarbon concentrations ranging 1 to 10 ppb, but appear to become temporarily disoriented.
- Salmon behavior during disorientation was characterizedby an extended period of searching and negative rheotactic movement.
- Disorientation caused a temporary disruption of the return migration but did not prevent the eventual return to the home stream.

These findings suggest that pink salmon encountering an oil spill along their migratory route may not be exposed to levels causing tainting or mortality. Instead disoriention to low hydrocarbon concentrations would cause the fish to retreat back along the migratory route until orientation was reestablished. This may result in a delay in migration that could have a significant effect on the time of spawning and subsequent survival of offspring or cause straying to other streams where the probability of survival would be lower.

STUDY RESULTS: Salmon returning toward the home stream through uncontaminated waters exhibited two types of movement behavior. After release from the holding pen salmon showed a searching behavior that was characterized by (1) variable horizontal movements that were generally directed up bay against the ebb current with short periods of movement either across or with the current, (2) movement up and down in the water column with a higher frequency of large-amplitude compared to small-amplitude vertical movements, (3) and swimming at a slow speed (mean ground speed 0.26 m/s). When fish began to move along a straight horizontal course toward the home stream the amplitude of vertical movement decreased and swimming speed increased (mean ground speed 0.46 m/s). The latter behavior was defined as an active migration behavior.

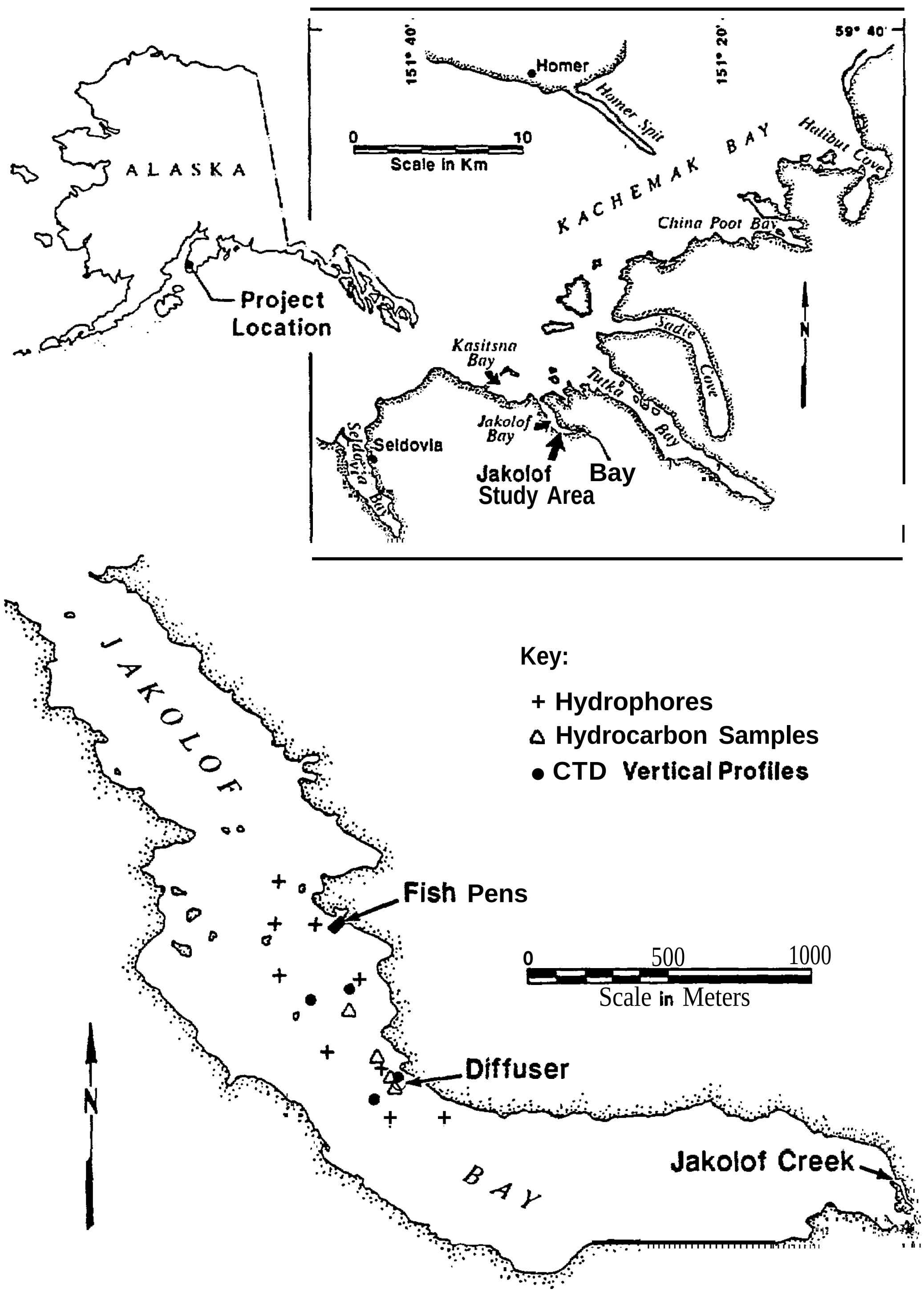
Differences in movement behavior of salmon during Treatment 3 compared to the behavior of salmon during the control experiments indicated that hydrocarbon concentrations ranging 1.0 to 10.0 ppb caused a temporary disruption of the salmon migration to the home stream. Fish exposed to contaminated waters spent significantly more time conducting searching movements and showed negative rheotactic movements. Following this behavior salmon displayed an active migration behavior (positive rheotaxis) and successfully returned toward the home stream by migrating initially through low hydrocarbon concentrations (i.e., approximately 1.0 ppb) along the plume edge and finally through uncontaminated waters outside of the plume. The location of the return route was similar to the return route used by fish during the control experiments, indicating the home stream chemical cues, which are used for orientation, were not completely contaminated by the hydrocarbon plume.

The change in movement behavior and the resulting delay of the return migration after oil exposure is thought to be a result of disorientation, which may have been caused by chemosensory impairment. This conclusion is based on the following evidence:

- A consistent display of negative rheotactic movements by salmon exposed to oil suggests the fish were unable to detect the return route (home stream cue) , and thus headed down bay in search of home water. Previous research has found that if salmon lose the home stream cue during upstream migration they will return back downstream until they reestablish contact with the home water.
- The inability of salmon exposed to oil to detect the home stream cue even though search movements outside of the plume crossed the eventual return route suggests the chemosensory capabilities may have been impaired. The duration of impairment was temporary as indicated by the eventual successful return toward the home stream.

The conclusions of this study should be viewed with caution because they are based on a small amount of information. Further research is necessary to verify the consistency of the avoidance/disorientation response of salmon to low hydrocarbon concentrations, to determine the behavior and fate of salmon encountering a spill that contaminates either the entire width or a portion of the migratory route, and to investigate olfactory responses at exposure levels (concentration and duration) similar to those observed in this study.

STUDY PRODUCTS: Martin, D.J., D.I. Austin, C.J. Whitmus, L.A. Brocklehurst, and A.E.Nevissi. MS. Response of migrating adult pink salmon exposed to oil in a coastal bay. Submitted to Transactions of American Fisheries Society.


ALASKA
Project Location
151° 40'
Homer
Homer Spit
151° 20'
59° 40'
0
10
Scale in Km
KACHEMAK BAY
Halibut Cove
China Poot Bay
Kasitsna Bay
Sadie Cove
Tutka Bay
Jakolof Bay
Seldovia
Seldovia Bay
Jakolof Bay Study Area
N
JAKOLOF
Key:
+ Hydrophores
Δ Hydrocarbon Samples
● CTD Vertical Profiles
Fish Pens
0 500 1000
Scale in Meters
Diffuser
BAY
Jakolof Creek
N

1.0 INTRODUCTION

1.1 BACKGROUND

The North Aleutian Basin including Bristol Bay has the most valuable concentration of salmon in North America. All five species of Pacific salmon (sockeye, pink, chum, coho, and chinook) pass through this region enroute to their home streams for spawning. Fishery management agencies are concerned that oil and gas development in this region could have significant impacts on salmon. An issue of particular concern is that an accidental oil spill in the path of migrating salmon may disrupt their spawning migration. The response of migrating adult salmon during exposure to oil in coastal or open ocean water has never been investigated. Therefore, resource management agencies requested information that would be needed before decisions could be made concerning oil development in the North Aleutian Basin.

In 1986, the National Oceanic and Atmospheric Administration (NOAA) and the Minerals Management Service (MMS) initiated a two-phased project to investigate the effects of petroleum contaminated waterways on spawning migration of Pacific salmon. Phase I consisted of laboratory studies to determine the chemosensory detection threshold for oil by adult salmon and the effects of oil on salmon chemosensory function. Phase II, this study, consisted of field experiments to determine if the migration of adult salmon would be disrupted by exposure to oil contaminated waters at concentrations near or above the chemosensory detection threshold.

The laboratory studies of Phase I were conducted by Pearson et al. (1987). They exposed adult coho salmon held in a freshwater aquarium to the water-soluble fraction (WSF) of crude oil and measured the electrophysiological response of the olfactory mucosa. They found that adult coho salmon have a chemosensory detection threshold of 10”7 ug/L (ppb). At concentrations of 0.1 to 1.0 ppb of WSF, the chemosensory response was degraded but not irreversibly. A return of the chemosensory detection response at lower levels of WSF suggested to the investigators that high hydrocarbon levels were causing a temporary narcosis. Exposures to WSF concentrations less than 0.1 ppb did not impair the ability of salmon to detect biologically relevant cues.

Based on the laboratory findings of Phase I, Pearson et al. (1987), concluded that

- Coho salmon have the sensory ability necessary to avoid oil contaminated waters;
- The degradation of the chemosensory response at exposure levels above 1 ppb suggests that if salmon encounter high exposure levels they may have impaired ability to detect and avoid oil-contaminated areas; and
- If salmon encounter oil concentrations less than 1 ppb and do not avoid the oil, they should be able to migrate through the oil-contaminated areas without becoming disoriented.

Based on these conclusions, a field investigation was designed to address the following questions

1. Will migrating adult salmon avoid oil-contaminated waters at concentrations near or above the chemosensory detection threshold?

2. If adult salmon encounter WSF concentrations above 1.0 ppb, will they become disoriented?

3. If adult salmon avoid or become disoriented by oil contaminated waters, does either response disrupt migration to the home stream?

In order to address these questions it is necessary to understand the mechanism for salmon orientation and migration in nearshore waters. Research has indicated that salmon depend on chemosensory detection of chemical cues for orientation during migration in coastal waters (Bertmar and Toft 1969, Westerberg 1984, and Doving et al. 1985). Westerberg (1983b) and Doving et al. (1985) have shown that salmon movements are closely related to the fine-scale vertical layering of the water, which contain the home stream odorant. Salmon seek these information-giving layers by large-amplitude vertical movements and maintain orientation within these layers by small-amplitude zigzag movements through the interface layer of strong vertical density gradient (Doving et al. 1985). If salmon lose their olfactory sense, which Doving et al. (1985) tested by surgically severing the olfactory nerve, the salmon do not seek specific depths, they swim with larger amplitude movements, and they swim at a greater depth, often following bottom contours. This demonstrates the importance of olfaction during the coastal phase of migration. During the freshwater phase of migration, salmon will seek the home stream cue at tributary junctions by horizontal zigzag movements along the edge of the scented and unscented plume (Johnsen and Hasler 1980). In the presence of the home stream cue, salmon will make straight positive rheotactic movements and in the absence of the home stream cue, they become negatively rheotactic and swim downstream (Johnsen 1982).

This study provides observations of adult salmon behavior during migration through coastal waters to the estuary of their home stream. Observations of fish movements through coastal waters with and without oil contamination are compared in order to identify behavioral responses to oil exposure. The results of this investigation coupled with our knowledge of salmon migration behavior have lead us to believe that migrating salmon become disoriented when exposed to oil contaminated waters.

1.2 OBJECTIVES

Specific objectives addressed in Phase II were to

1. Identify the behavior of migrating adult salmon exposed to oil contaminated waters at concentrations ranging from the chemosensory detection threshold to greater than 1.0 ppb,

2. Determine if avoidance or disorientation by adult salmon to oil contaminated waters will disrupt migration to their home stream, and

3. Relate the documented avoidance, non-avoidance, or disorientation by salmon of oil-contaminated waterways to possible effects of oil spill toxicity, tainting, and disruptions in migration.

2.0 METHODS

2.1 DESCRIPTION OF THE STUDY AREA

Field experiments were conducted in Jakolof Bay, which is located on the south side of Kachemak Bay near Seldovia, Alaska (Figure 2-1). Jakolof Bay is approximately 3.5 km long, 0.5 km wide, and ranges from 1 m to 10 m deep at mean lower-low-water (mllw). The shorelines are mostly rocky with some gravel beaches along the southwestern side. The uplands are wooded and undeveloped for the most part. A gravel road runs along the south side to an inoperative sawmill near the head of the bay. A small boat dock that is used for recreational boaters is located on the western shore just inside the mouth of the bay. Freshwater enters Jakolof Bay from Jakolof Creek and several small intermittent streams. Jakolof Creek is a permanent stream approximately 5 km long and enters at the head of the bay. Annual runs of pink and chum salmon to Jakolof Creek range from several hundred to several thousand fish, with a maximum combined run of 12,000 fish (Tom Schroeder, Alaska Department of Fish and Game, Homer, personal communication).

Jakolof Bay was selected for the field investigation because of its geographic location, configuration, and fish resources. Jakolof Bay is located 2 km from NOAA's Kasitna Bay Station (Figure 2-1), which provided laboratory facilities, logistic support facilities, and lodging. The long narrow configuration of Jakolof Bay with Jakolof Creek at the head of the bay provided a confined coastal area along the migratory route of pink and chum salmon. The bay is closed to commercial salmon fishing, which was necessary to preclude the loss of test fish and to minimize disturbance of test equipment. Jakolof Creek has a native run of pink salmon of sufficient number to provide test fish for the study. The shallow, well-mixed characteristics of Jakolof Bay are ideally suited for development of a hydrodynamic model, which is an important component of the study.

2.2 EXPERIMENTAL DESIGN

The response of adult salmon exposed to oil-contaminated waters was studied by tracking pink salmon movements through Jakolof Bay during periods with and without oil contamination. Ultrasonic transmitters were attached to adult salmon, which were captured at the mouth of Jakolof Creek (Figure 2-2). During an ebb tide, the tagged salmon were released from a holding pen located 2 km from Jakolof Creek and their movements were tracked by a fixed array of hydrophores as the fish returned to their home stream (Figure 2-2). The horizontal and vertical position of each fish within a test group was recorded continuously. Fish horizontal and vertical movement patterns, swimming speed, and duration-of-return to the home stream were examined in order to identify behavioral responses to oil exposure.

A solution of aromatic hydrocarbons similar in composition to the WSF of Prudhoe Bay crude oil was injected into the water column from a diffuser located midway between the fish holding pen and the mouth of Jakolof Creek (Figure 2-2). The diffuser was designed to create a vertically mixed hydrocarbon plume, which extended north from the diffuser and along the eastern one-half of the bay. Salmon were released from the holding pen when the hydrocarbon plume had extended approximately 300 m downfield. This enabled the salmon to have an option of either moving into or around the plume. Hydrocarbon dispersion rate and concentration within the plume were estimated from a hydrodynamic model, which was calibrated by dye dispersion studies. Predicted hydrocarbon concentrations were also verified with analysis of water samples. The hydrodynamic model and diffuser design were developed from oceanographic data that were collected from a reconnaissance survey conducted during April 1988. The salmon tracking experiments were conducted during late July to correspond with the spawning migration of pink salmon to Jakolof Creek. Tracking experiments conducted without hydrocarbon discharge were designated as ‘controls” and experiments with hydrocarbon discharge were designated as “treatments.” Three control experiments and three treatment experiments were conducted on an alternating schedule during the period from July 19 to July 29. One control experiment had to be repeated because of high winds, which affected the performance of the experiment. Experiments were not conducted for a minimum of two days following each treatment run in order to allow time for the hydrocarbon plume to be flushed from the bay.

Prior to the salmon tracking experiments, an accidental discharge of fuel oil occurred from a tugboat moored near the saw mill on the south side of Jakolof Bay. The oil spill, which occurred on July 17, contaminated the beaches and surface waters near the head of Jakolof Bay. There was a concern that the spilled oil would interfere with the salmon tracking studies. Therefore, an investigation was conducted to determine the concentration and composition of the oil-contaminated waters. The results of this investigation are summarized in Section 3.2.1, as they pertain to background conditions, and a complete description of the results from this investigation is provided by Payne et al. (1988).

2.3 PERMITTING

In order to conduct this study, several permits and a public meeting were required by the State of Alaska. All permit requests and reviews were coordinated by the Alaska Division of Governmental Coordination. Section 307 (c) (1) of the Federal Coastal Zone Management Act requires certification that any activity, which may affect land or water uses in Alaska, will comply with the standards of the Alaska Coastal Management Program. Compliance with this program required three agency permits:

1. Alaska Department of Fish and Game (DFG) - Special Use Permit.

2. Alaska Department of Environmental Conservation (DEC) - Oil Discharge Permit for Scientific Purposes.

3. Alaska Department of Natural Resources (DNR) - Land Use Permit.

These permits stipulated measures necessary to prevent significant contamination of the environment, minimize disturbance of aquatic habitat, and minimize interference of public access to the waters of Jakolof Bay. The public meeting was advertised in the local media and was held in Homer, Alaska. The purpose of this meeting was to inform the public about the study and to gather information on public use of the project area and any public concerns. Consideration for potential impacts to public resources were subsequently addressed by the permit stipulations. The time from permit application to final authorization was six months.

2.4 PLUME MODELING

A numerical dispersion model was use to design a diffuser for injection of a hydrocarbon solution into Jakolof bay and for predicting the fate of hydrocarbons in the bay. Different mechanisms dominant the dispersion process in the near-field and far-field; therefore, models were applied to the simulation of plume behavior in each zone. In the near-field, discharge momentum and buoyancy effects are important; in the far-field, advection and large-scale mixing dominate. The far-field begins, by definition, when the plume buoyancy and momentum match the ambient conditions. The diffuser function and initial plume behavior in the near-field were modeled using a three-dimensional plume model. A two-dimensional far-field model was applied to simulate plume behavior under ambient conditions.

2.4.1 Model Descriptions

2.4.1.1 Near-Field Model

The near-field flow dynamics and dispersion were simulated using the EPA Plume series of models (Muellenhoff et al., 1985). The models were designed for National Pollution Discharge Elimination System (NPDES) permitting and are based on the mixing zone concept for positively buoyant plumes. The Plume series of models predict the spatial dimensions and concentrations of an effluent along single or multi-port discharges. Input parameters required are: current velocity, water temperature, and salinity distributions over the depth of the water column; discharge density; and, discharge rate. A self-similar Gaussian distribution of the cross-plume velocity and concentration profiles is assumed in most of the models. The port size, spacing and discharge angle can be varied as required. Output from the models include the plume centerline position, lateral dimensions and flux-averaged concentration.

2.4.1.2 Far-Field Model

The Dames & Moore proprietary hydrodynamic program TIDAL2 and associated water quality program WQUAL2 are finite-difference, depth-averaged models designed to simulate the circulation patterns and the resulting water quality parameter distributions in tidal water bodies (Dames & Moore, 1985). The models integrated finite differences (or nodal point integration) to represent the governing equations. They are solved using a space-staggered, split-time-level, semi-implicit scheme (see Leendertse, 1970). The programs have been used to study a wide variety of problems ranging from the analysis of pollutant discharge in tidal water bodies to the effect of bathymetric modifications on geostrophic or wind-driven current patterns. TIDAL2 is based on shallow-water equations and WQUAL2 uses heat and mass transfer equations (Stoker, 1957). Both models solve the vertically integrated form of the governing equations. Variable grid spacing has been incorporated into the models in order to obtain higher resolution in areas of particular interest.

Far-field water quality modeling of each discharge was performed in two steps. First, the hydrodynamic program TIDAL2 was run to obtain the current patterns in the bay using the tides at the mouth of the bay as the driving mechanism. Second, the values of the current velocity and water level at each finite difference grid point were stored and then used as input to the water quality program. Source terms for the water quality program (flow rate and concentrations) were input from the near-field program. Output from the program includes printerplots, tabular output and data for plotting.

Data required by the far-field model include the bathymetric, oceanographic and numerical data necessary to run the model. Bathymetry data were obtained from National Ocean Service (NOS) data files, which were used to prepare the NOS navigation charts for Jakolof Bay. Oceanographic data, specifically tides and currents, required to develop boundary conditions and provide data for the calibration phase, were obtained from field measurements (see Section 2.4.2 and the NOS tide tables for Seldovia.

2.4.2 Oceanographic Data Collection

Oceanographic and atmospheric data collected in support of this study were designed to provide input and calibration data for the hydrodynamic model of Jakolof Bay. Oceanographic parameters measured included current speed and direction, tide height, temperature, and salinity. Atmospheric parameters measured consisted of wind and barometric pressure. Measurements were conducted during April (reconnaissance survey) and during the main experiment period in July.

2.4.2.1 Field Methods

Reconnaissance Survey

During the reconnaissance survey currents were measured with drift sticks. Groups of 6 to 8 drift sticks (2.5-cm by 10-cm by 120-cm boards with a weight on the bottom and a flag on the top) were released along a transect across the bay. Positions were determined every 15 to 30 minutes by tracking each drift stick with a small boat equipped with a Motorola Mini-Ranger III. Estimates of the current speed along the bay and variability across the bay were determined from trajectory plots for each drifter.

Currents were recorded for a period of one month at four locations within Jakolof bay (Figure 2-3) using Aanderaa RCM-4 current meters. The meters were configured to measure current speed and direction, water temperature, and conductivity at five minute intervals. A pair of meters, one near surface and another near bottom, were deployed at stations 1 and 2. One meter was deployed near the bottom at stations 3 and 4. During mid-May the meter at station 1 was redeployed for an additional month after discovering that the mooring had moved from its initial location. At times of extremely low tides, the meters at stations 3 and 4 came out of the water. Tide height was recorded by Aanderaa WLR-5 tide gages, which were mounted near the bottom at stations 1 and 2.

A dye tracking study was attempted in order to measure the along-bay and cross-channel dispersion rates of a Rhodamine dye in solution. This study failed, however, because of an inadequate dye dispersion mechanism, an insufficient instrument capability to rapidly detect and record the narrow dye plume, and poor weather conditions during the field period.

Wind speed was measured with a hand held anemometer and wind direction was estimated visually.

Main Program

Parameters measured during the main experimental program in July were identical to those measured in April-May; however, sampling locations and patterns changed. Three Aanderaa RCM-4 current meters and one Aanderaa WLR-5 tide gage were deployed within a 1 km long study area in Jakolof Bay (Figure 2-3). Meters were mounted near the bottom at all stations and one meter was mounted near the surface at station 2. Tide height was measured at station 2. Wind speed and barometric pressure were measured by recording instruments located on a small island in the center of the study area (Figure 2-3). Wind speed was measured with an R.M. Young wind anemometer and data were recorded with a Campbell Scientific CR 10 data logger. Barometric pressure was measured with a pressure sensor but the data from this instrument was inaccurate as a result of equipment malfunction.

Dye tracking studies were conducted in order to predict the distribution and dispersion of the projected hydrocarbon plume in Jakolof Bay. Rhodamine dye was released from the oil discharge diffuser (see Section 2.4.3) during an ebb tide and was tracked by a small boat equipped with a Turner Fluorometer and Mini-Ranger positioning system. Transects were conducted across and along the plume with the fluorometer intake hose placed at 4 m deep. Vertical profiles of the plume were also conducted periodically during each survey. Boat position and Turner fluorometer values were recorded manually once every 30 seconds. A Turner Designs data logger was also used to automatically record data at one-half second intervals; however, this instrument frequently did not operate correctly. Five dye surveys were attempted; however, usable data were obtained from only two surveys. Malfunctions of the automatic data recording system prohibited using data from the other surveys.

In order to determine the vertical density structure of Jakolof Bay during the fish tracking experiments, water temperature and conductivity y were sampled at 12 sites located along three transects of the bay (Figure 2-3). Vertical profiles of the water properties were measured at one meter depth intervals from the surface to bottom. The measurements were made using an Aanderaa RCM-4 current meter without vane and station positioning was determined with a Mini-Ranger. This sampling scheme was followed during the second and third pairs of experiments. During the first pair of experiments, vertical profiles were only performed near the hydrocarbon discharge diffuser.

2.4.2.2 Data Processing

April and July field measurements were processed in a similar manner as follows

1. All Mini-Ranger data were scanned for obviously erroneous points and those points were eliminated, or corrections made if surrounding data permitted interpolation.

2. Positions of all sampling stations and all drifter trajectories were plotted and checked against field maps.

3. Aanderaa current meter recordings were transferred from magnetic tape to disk using an Aanderaa tape reader. The NOAA supplied meter calibration equations were utilized to transpose the recorded Aanderaa units to actual current speed and direction, temperature, conductivity, and pressure readings. Salinity and density were then calculated using a standard computation routine obtained from the University of Washington. Time series plots of each recorded parameter were plotted and obviously bad data points, as well as pre- and post-deployment recordings, were removed. All suspicious data points (e.g., when the current meter at station 1 moved during April or periods when a meter was out of the water) were removed from the data set. In some cases, it also appears that some meters did not rotate freely during their deployment. In these cases, the data were not removed because the current speed appears accurate; however, the directional data are questionable.

4. Time series of wind speed and direction were plotted and edited for bad data.

5. Water property measurements were used to compute the salinity and density of the water. Vertical profiles of salinity were prepared for selected stations along each transect.

6. Dye concentrations were computed from the manually recorded Turner fluorometer voltage outputs, which were based on daily calibrations of the instrument. The calibration curve derived from these tests is shown in Figure 2-4. Measured concentrations of the dye along each survey transect were plotted and contoured.

2.4.3 Diffuser Desire

A submerged diffuser was used to introduce the hydrocarbon solution into the water column with the objective of creating a plume of sufficient size and concentration that would intercept and potentially af feet salmon migrating through Jakolof Bay. A hydrocarbon plume 10 to 30 m wide and 100 to 150 m long with a concentration of 10 ppb was assumed sufficient given the uncertainties involved (e.g., salmon migratory route, swimming speed, and plume dispersion). Initial calculations indicated that a multi-port diffuser located on the sea bed would be best suited to meet the design criteria. The results of the reconnaissance survey were used in the near-field plume model to develop the final diffuser design.

2.4.3.1 Results of Reconnaissance Survey

Measurements of currents and density structure taken during the reconnaissance survey were used to finalize the design of the diffuser system, The current meters located near the proposed diffuser site (i.e., April stations 2 and 3, Figure 2-3), recorded maximum currents of 0.38 m/s (0.74 knots) and 0.10 m/s (O. 19 knots) during the spring tide and neap tide ebb flows, respectively. Water depths at these tides and a typical density profile are shown in Table 2-1.

Table 2-1: Diffuser Operating Conditions

Tide class	Maximum Current(m/s)	Minimum Depth(m)	Maximum Depth(m)
Spring	0.38	1	8.5
Neap	0.10	3	6.7

Depth (m)	Temperature (Deg C)	Salinity (ppt)
0.0	5.43	28.1
1.0	4.88	30.5
2.0	4.66	31.0
3.0	4.63	31.1

2.4.3.2 Diffuser Parameters

Hydrocarbon dispersion (mixing) in the water is a function of the initial discharge velocity (momentum), the ambient currents, the vertical stratification, and the relative density (buoyancy) of the discharge and the receiving waters. The greater the initial velocity and mass discharged, the further the plume will penetrate into density stratified water. However, the energy required to obtain a particular velocity is proportional to the square of the velocity, so the horsepower of the pump required rapidly increases at higher discharge velocities. Strong density stratification suppresses mixing while strong currents generally enhance mixing.

The variables considered in the diffuser design included the following:

“Length and diameter of diffuser pipe
“Number, size, and spacing of ports
“Angle of the ports relative to the current
“Diffuser exit velocity and hence pumping rate
‘Water depth and current velocity
° Intake water density (depth of intake)
° Water column density profile

Considering hydrocarbon volubility led to an additional requirement of approximately 400 dilutions in the zone of initial mixing. Approximately 75 runs of the plume models were made in optimizing the diffuser design for the wide range of possible oceanographic operating conditions.

The final design of the diffuser system as built is shown in Figure 2-5. Intake water from approximately 1 m below the surface (to avoid fresh water from Jakolof Creek) was mixed with the hydrocarbon solution using a vacuum inlet and was pumped into the diffuser with an 8 horsepower pump. Hydrocarbon injection rate was regulated with a metering valve to produce an exit concentration of approximately 20 mg/L of the hydrocarbon solution. The diffuser consists of a 10 m long by 7.63 cm (3 inch) diameter pipe, which was oriented perpendicular to the current flow (cross bay). Discharge is through eleven 1.9 em (3/4 inch) diameter ports at 1 m centers facing vertically upwards. The pump can achieve a flow rate of 757 to 946 L/rein resulting in exit velocities of 5.0 to 5.5 m/s. Under most flow conditions the individual port plumes merge within 5 to 10 m of the diffuser to form an initial plume approximately 12 to 15 m wide and 2 to 3 m deep.

2.5 HYDROCARBON COMPONENTS

2.5.1 Hydrocarbon Stock Solution

2.5.1.1 Rationale for Using Hydrocarbon Cocktail

Experiments were conducted with a hydrocarbon solution "cocktail" that was similar in composition to the WSF of Prudhoe Bay crude oil. This cocktail was used instead of WSF because it provided a test solution with a known chemical composition and concentration that could consistently be replicated for each treatment. WSF produced by batch equilibration is not stable and can vary in concentration. Therefore, the WSF could not be prepared in advance of the field study. The hydrocarbon cocktail could be prepared in advance and could be stored indefinitely. The large volumes of WSF required to create a target concentration of 10 ppb in the far-field plume (see Section 2.4.3 Diffuser Design) was logistically not possible for this study. During the field experiments, 20 ml/min of cocktail added to a water flow of approximately 1000 L/rein resulted in a concentration of 20 ppm in the diffuser discharge. If WSF were used, its preparation could be achieved either by batch equilibration of crude oil with water (Nakatani et al. 1985), which yields about 20 ppm WSF/L of water, or by use of continuous-flow devices (Moles et al. 1985), which yields about 2-3 ppm WSF/L of water. The concentration of WSF at equilibrium with sea water is about 20 ppm, or 0.02 ml of WSF/L of sea water. This equilibrium concentration could have been produced with a crude oil to water ratio of 1:100. To produce 20 ml/min of pure WSF, a flow of 1,000 L/rein of water in equilibrium with 10 L of crude oil would have been needed. During a 3-hour hydrocarbon release, the volume of water and the volume of crude oil would have been 1.8 x 10^5 L and 1,800 L, respectively. On the other hand, if a continuous-flow device operating at 3 ppm (or 15% of equilibrium) were used, the volume of crude oil per experiment would have been 12,000 L and the rate of pumping water to the diffuser would have been 6,666 L/rein. The elaborate logistics needed to set up extraction facilities to produce this much WSF in the field and to dispose of the waste crude oil were beyond the capabilities of this study. Additional permitting requirements for this work would likely have postponed the research in 1988.

2.5.1.2 Composition of Hydrocarbon Cocktail

The WSF of crude oil is defined as a single phase, homogeneous mixture of hydrocarbons passed through a 0.45-um filter to eliminate colloidal dispersions and oil-in-water emulsions (National Research Council 1985). A water-soluble fraction produced in the laboratory is an artificial mixture and cannot be used to simulate precisely the conditions of hydrocarbon composition and concentration that occur when oil is spilled in the marine environment (National Research Council 1985). Equilibration conditions in the real world are quite different from the laboratory conditions under which the WSF is produced. The WSF produced in the laboratory represents a compromise, a means of generating a highly reproducible and relatively stable oil-in-water mixture.

The WSFS of crude oil prepared and used by different investigators do not necessarily follow the above definition and may differ widely in composition of hydrocarbons. This may be partly due to instability of WSF under nonequilibrium conditions and partly due to analytical difficulties in measuring the highly volatile components of the WSF. For these reasons, only the nonvolatile components of WSF, mainly aromatics and long chain aliphatics, are usually referred to as the major components of the WSF. For example, Pearson et al. (1987) prepared WSF by equilibrating Alaskan North Slope crude oil with artificial pond water. This WSF was composed of 97% monoaromatic and 3% polyaromatic hydrocarbons. Moles et al. (1985) extracted WSF with a flow-through device and reported that 96.5% of the measured hydrocarbons were monoaromatics (i.e., benzene, toluene, and xylenes) and 3.5% were polyaromatics. The National Research Council (1985) reported the WSF composition of five reference oils as containing 94 to 99% monoaromatics, 1 to 4% di- and tri-aromatics, and 0.4 to 1.9% n-paraffins (C_{12} to C_{24}). Light n-paraffins and cycloparaffins (C_1 to C_{10}) are usually not measured in the WSF because of their high volatility, although these compounds can constitute a large proportion of the WSF.

The composition of the cocktail used in this study (Table 2-2) was made as close as possible to the composition of WSF of Prudhoe Bay crude oil, but differed widely from the WSF reported above. Research at the University of Washington (Nakatani et al. 1985) found the WSF of Prudhoe Bay Crude Oil was composed of 54.90/0 aromatics, 6.8% cycloalkanes, and 38.2% alkanes. These results indicate a much lower proportion of aromatics than was reported by other analyses. This discrepancy between analyses is thought to be due to differences in analytical measurement technique. The former analyses most likely exclude the volatile components of the WSF.

Table 2-2. Composition of the hydrocarbon (cocktail) mixture used compared with the water-soluble fraction (WSF) of Prudhoe Bay crude oil.

Hydrocarbon	WSF[a] (% Weight)	Cocktail Mixture (ml)	(g)	(% Weight)
Methane	0.87	--	--	--
Ethane	7.33	--	--	--
Propane	14.45	--	--	--
Isobutane	2.12	--	--	--
n-Butane	8.02	--	--	--
Isopentane	1.71	750	470	15.8
n-Pentane	2.27	930	580	19.5
2,2-Dimethylbutane	0.03	--	--	--
Cyclopentane + 2-methylpentane	1.50	64	42	1.4
3- Methylpentane	0.24	10	7	0.2
n-Hexane	0.54	22	15	0.5
Methylcyclopentane	1.23	--	--	--
Benzene	24.70	844	741	24.9
Cyclohexane	2.24	86	67	2.3
n- Heptane	0.64	56	38	1.3
Methylcyclohexane	0.89	58	45	1.5
Toluene	17.83	617	535	18.0
Octanes or cycloheptanes	0.21	--	--	--
Octanes or cycloheptanes	0.20	--	--	--
Octanes or cycloheptanes	0.36	38[b]	33	1.1
Octanes or cycloteptanes	0.25	--	--	--
Ethylbenzene	1.23	128	111	3.7
m-, p-Xylene	4.59	250[c]	217	7.3
o-Xylene	2.78[c]	--	--	--
Isopropylbenzene	0.39	51	45	
C3 Benzenes (methylbenzenes)	1.11	--	--	--
o-Methylethylbenzene	0.41	--	--	--
1,2,4 -Trimethylbenzene	0.73	--	--	--
1,2,3 -Trimethylbenzene	0.27		--	--
Naphthalene(s)	0.87	26 g	26	0.9
% Total alkanes	38.21	--	--	37.3
% Total cycloalkanes	6.88	--	--	6.3
% Total aromatics	54.90	--	--	56.3

[a] From Nakatani et al. 1985.
[b] Normal octane.
[b] xylenes.

A mixture of hydrocarbons in approximately the same proportions as are present in the WSF of Prudhoe Bay crude oil (Table 2-2) was prepared. Hydrocarbons that were difficult to add to the mixture under normal conditions (e.g., gaseous hydrocarbons, methane, ethane, propane, and butane) and hydrocarbons that were hard to obtain (e.g., 2,2-dimethylbutane, methylcyclopentane, and methylbenzenes) were omitted from the mixture. Hydrocarbons similar to those that were omitted were added to the mixture in order to simulate as closely as possible the dissolved hydrocarbons in equilibrium with the WSF of Prudhoe Bay crude oil. The make-up hydrocarbons were usually in the same class of hydrocarbons immediately higher or lower in carbon number. The largest additions were isopentane and n-pentane, which replaced the gaseous hydrocarbons that were difficult to handle and include in the mixture.

2.5.2 Water Sampling and Hydrocarbon Analysis

2.5.2.1 Sample Collection

Water samples were collected from five locations along Jakolof Bay (Figure 2-6) during the April reconnaissance survey and again prior to the July study for background measurements of hydrocarbons. During the tracking experiments samples were collected at varying depths at locations both up- and down-bay from the diffuser (Figure 2-6).

Water samples were collected by means of a small 12-volt electric pump. A Tygon intake hose was lowered to the sampling depth and the pump was run for a few minutes to rinse the pump and the hose. Sample containers were also rinsed several times with water from the pump prior to the collection of a sample. The boat was kept on station by means of a Miniranger.

Water samples were collected from the intertidal area by hand. A sample bottle capped with aluminum foil was submerged upside down after the surface microlayer was pushed aside to avoid contamination. While submerged, the bottle was turned right side up and filled under the surface.

Water samples for analysis of Cl to C_{10} hydrocarbons were collected in 500-ml crown-cap bottles. The bottles were pre-cleaned in the laboratory by washing with detergent and hot water, rinsing with dichloromethane (CH_2 to Cl_2), and drying at 200°C. The bottles were capped with aluminum foil and boxed for shipment to the field station. In the field, the bottles were uncapped, rinsed with the water to be sampled, and then completely filled with water to avoid any head-space. Samples were preserved by adding 1 ml of saturated mercuric chloride ($HgCl_2$) and capped. These samples were returned to Seattle for analysis by gas chromatography (GC) using the multiple phase equilibrium technique.

Water samples for hydrocarbon extraction were collected in 20-L glass carboy bottles. The bottles were cleaned at the field station with detergent and sea water, and rinsed with dichloromethane. After collection, these samples were returned to the field station laboratory for extraction and analysis.

2.5.2.2 Hydrocarbon Measurement

Gas Equilibration and GC Analysis

Water-soluble volatile hydrocarbons (C_1 to C_{10}) were measured by GC using a multiple-phase equilibrium technique (McAuliffe 1969, 1971). A 25-ml water sample was drawn into a glass hypodermic syringe from the sample bottle under a helium atmosphere. An equal volume of helium was added and the syringe valve was closed. To establish equilibrium between gas and aqueous phases, the syringe was shaken vigorously for 5 minutes using a shaker. Twenty milliliters of the gas phase was then injected through the sample loop of the GC, and a measured volume was introduced for analysis. Materials, chromatography, integrator, and calibration procedures are described by McAuliffe (1980).

The total concentration of hydrocarbons found in the water samples was computed by summation of concentrations of each component, minus the Cl to C_4 hydrocarbons (i.e., methane, ethane, propane, and butane). These compounds were not added to the cocktail, and some of them, especially methane, are produced naturally in the sediment and released to the water column. The total hydrocarbon concentration is a measure of only those hydrocarbons found in the cocktail.

The detection limits of individual components of the cocktail were obtained by successive dilution of a concentrated solution of the cocktail in water (about 76 ppm) until the hydrocarbon in question was no longer detectable (Appendix A). For example, benzene in the concentrated solution was 45.7 ppm; after 20,000 times dilution a concentration of 0.55 ppb was considered the practical detection limit of benzene in the cocktail (Appendix A).

Solvent Extraction and GC Analysis

A GC setup for the analysis of C_{12} to C_{24} n-paraffin hydrocarbons was located at the NOAA Kasitsna Bay Laboratory. The use of this GC was not planned for this study because it did not have the necessary setup for analyzing the volatile hydrocarbons in the cocktail. However, it was used as an emergency measure to evaluate the effects of an accidental oil spill in Jakolof Bay, which occurred just prior to the study (see Section 2.2).

The methodology and the results of the solvent extraction analysis are presented in Appendix B. A more complete description of the analytical procedure and an evaluation of the effects of the oil spill on water quality are given by Payne et al. (1988).

2.6 SALMON TAGGING AND TRACKING

2.6.1 Test Fish And Transmitter Specifications

Adult pink salmon were obtained from the intertidal area at the mouth of Jakolof Creek (Figure 2-2) one to two days prior to each pair of tracking experiments (i.e., control/treatment). Salmon were caught with a 45-m long beach seine during either a low or a high slack tide. Fish were transported to the holding pens (two 3-m x 3-m x 1.5-m deep floating net pens) in several 240-L tanks.

The size of pink salmon used in all the tracking experiments averaged 50 cm and ranged from 41 to 60 cm (Appendix C). The male to female sex ratio for all test fish was 5644. Sex ratios of each test group were not similar among the tracking experiments (see Appendix C).

Sonic transmitters were attached to the test fish approximately 12 hours before each tracking experiment. Test fish were anesthetized with tricaine methanesulfonate (MS-222) and an external transmitter was attached to the fish beside the dorsal fin. The tag was held in place by two nickel pins that were pushed through the muscle of the fish and the ends were twisted down onto a plastic plate (Petersen disc type) on the opposite side of the fish. The tagging procedure did not injure the fish and did not have any noticeable effects on swimming behavior. Tracking experiments were initiated by allowing the fish to escape through a removable panel on the side of the floating net pen.

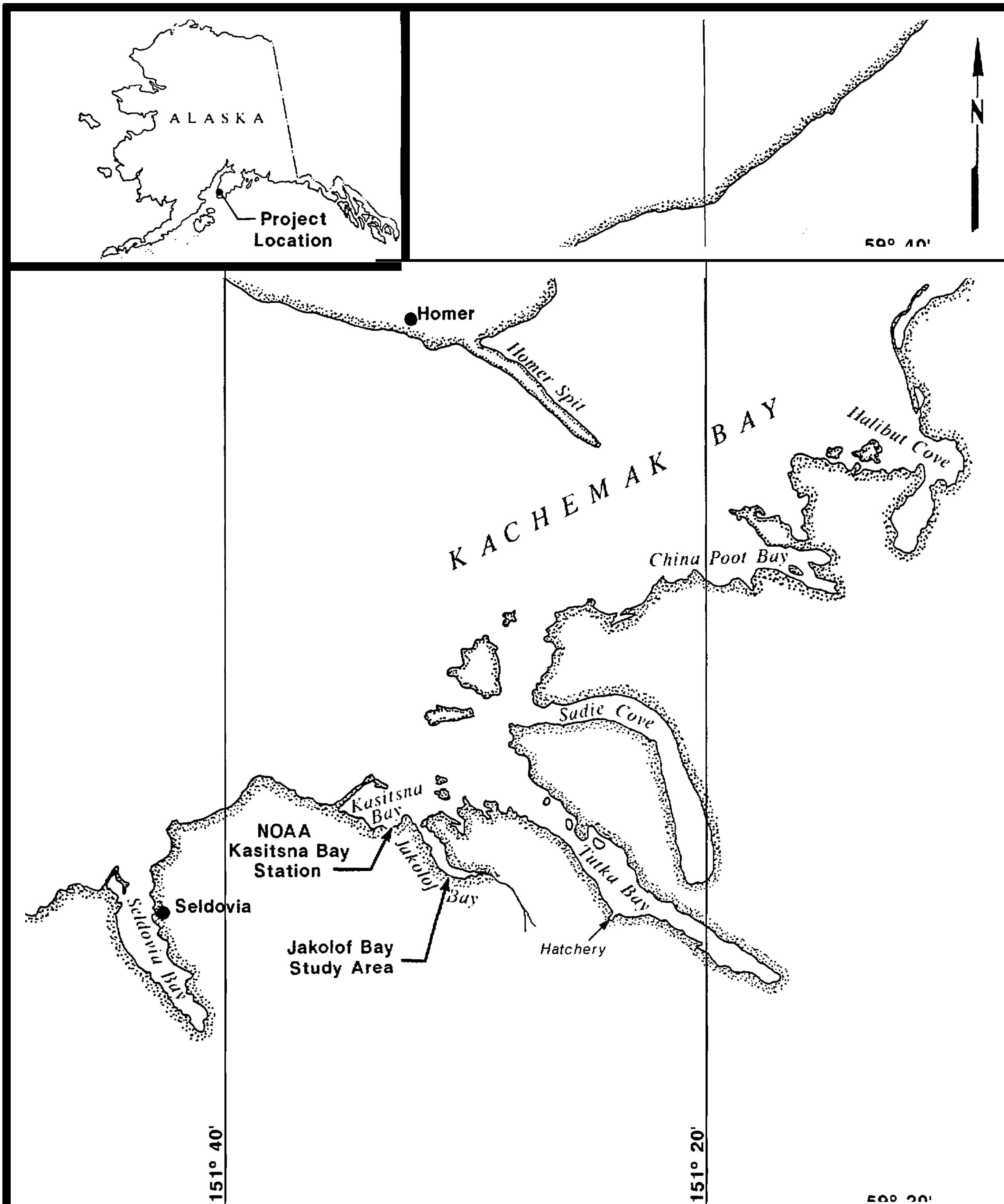
Each sonic tag had an individual identification code and pressure sensor. The pressure sensor had a depth precision of ± 15 cm. Both the identification code and the pressure sensor information were transmitted as two 8-bit codes by a sonic carrier at frequencies ranging 4 I to 45 kilohertz and 71 to 76 kilohertz. Tag size was 59.4 mm long by 12.2 mm in diameter and weighed 15.8 g in air.

2.6.2 Fish Tracking System

Fish positions were determined by measurements of signal time differences received by a fixed array of tuned hydrophores. Nine omnidirectional hydrophores placed 1 m off the bottom were located over a 1-km reach of Jakolof Bay (Figure 2-2). Each hydrophore was connected by coaxial cable to a sonic receiver station located on a small island at the edge of the hydrophore array. Output from the receiver was recorded on a 14-track recorder, which included time and voice logs. Following the field experiments the data was played back through an analog to digital converter, which was connected to a CRT plotter and a computer. Fish identification number and depth were determined from the plotter. A computer program was used to determine the time difference between time zero (i.e., first hydrophore to receive a tag signal) and delayed time arrivals from a minimum of two other hydrophores. This data was fed into a navigation program, which determined fish position (rectangular coordinates x and y) by solving for the intersection of two or more hyperbolas. Fish positions were determined at time intervals ranging from 0.5 to >10.0 min. Shorter intervals (i.e., 0.5 or 1.0 minutes) were used when the fish were moving fast and longer intervals were used when the fish were moving slow or were inactive.

2.6.3 Data Analysis

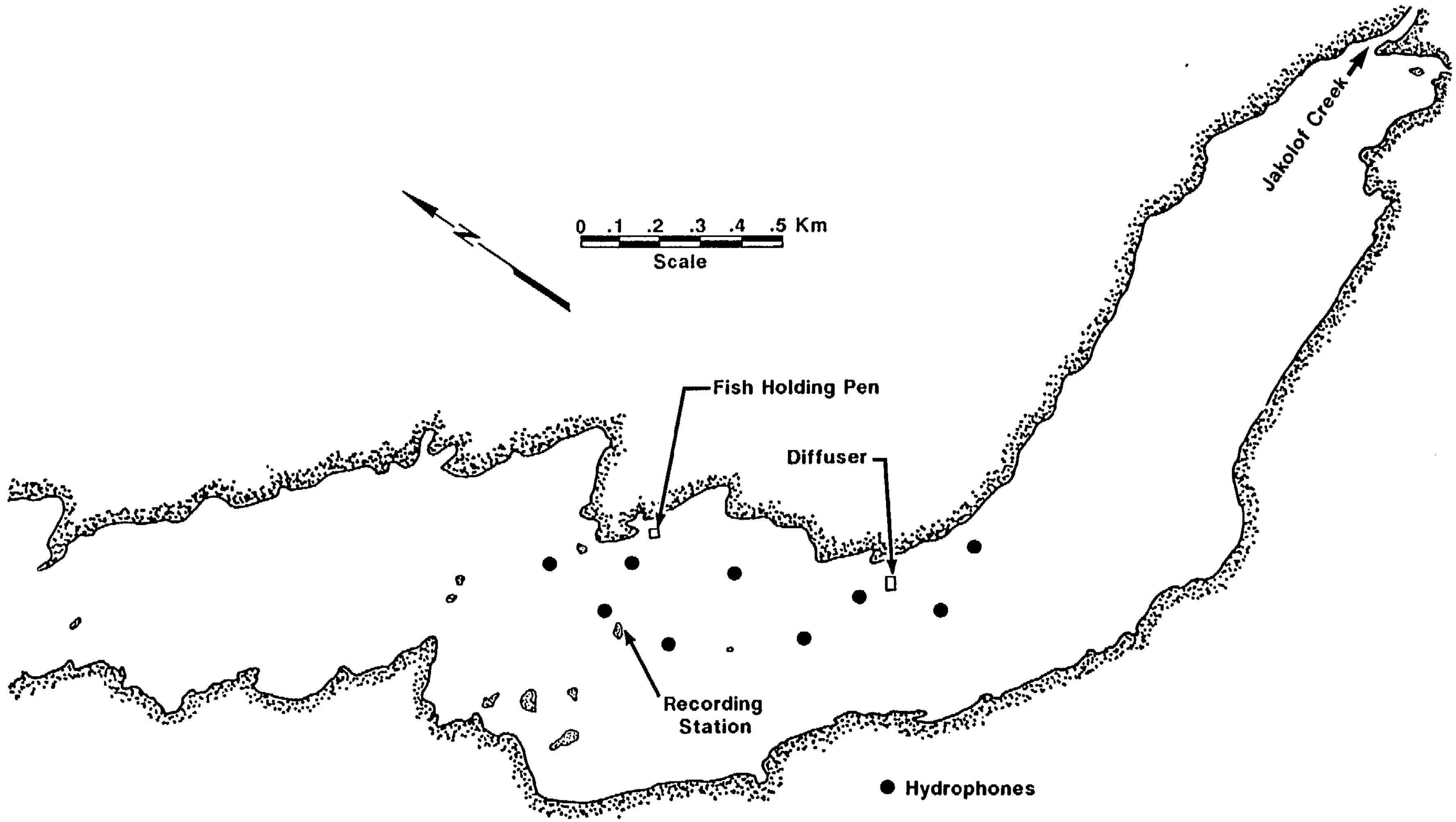
Movement patterns of pink salmon were determined by individual plots of fish horizontal position at selected time increments, fish depth versus time, and fish ground speed versus time. Ground speed was computed from the horizontal distance between adjacent fish positions and the time interval. All plots were created from the fish position and time data (Appendix D), which were generated from the fish tracking system. Fish behavior during exposure to the hydrocarbon plume was determined from plots of fish horizontal position superimposed on contour plots of the modeled hydrocarbon plume at selected time increments. The duration of fish exposure and the hydrocarbon concentration during exposure were determined from the integration of the fish position data with the hydrocarbon concentration data. The latter data were derived from the output of the plume model. Tests of differences in fish depth, duration-of-return period, and fish speed were performed by the Analysis of Variance procedure.



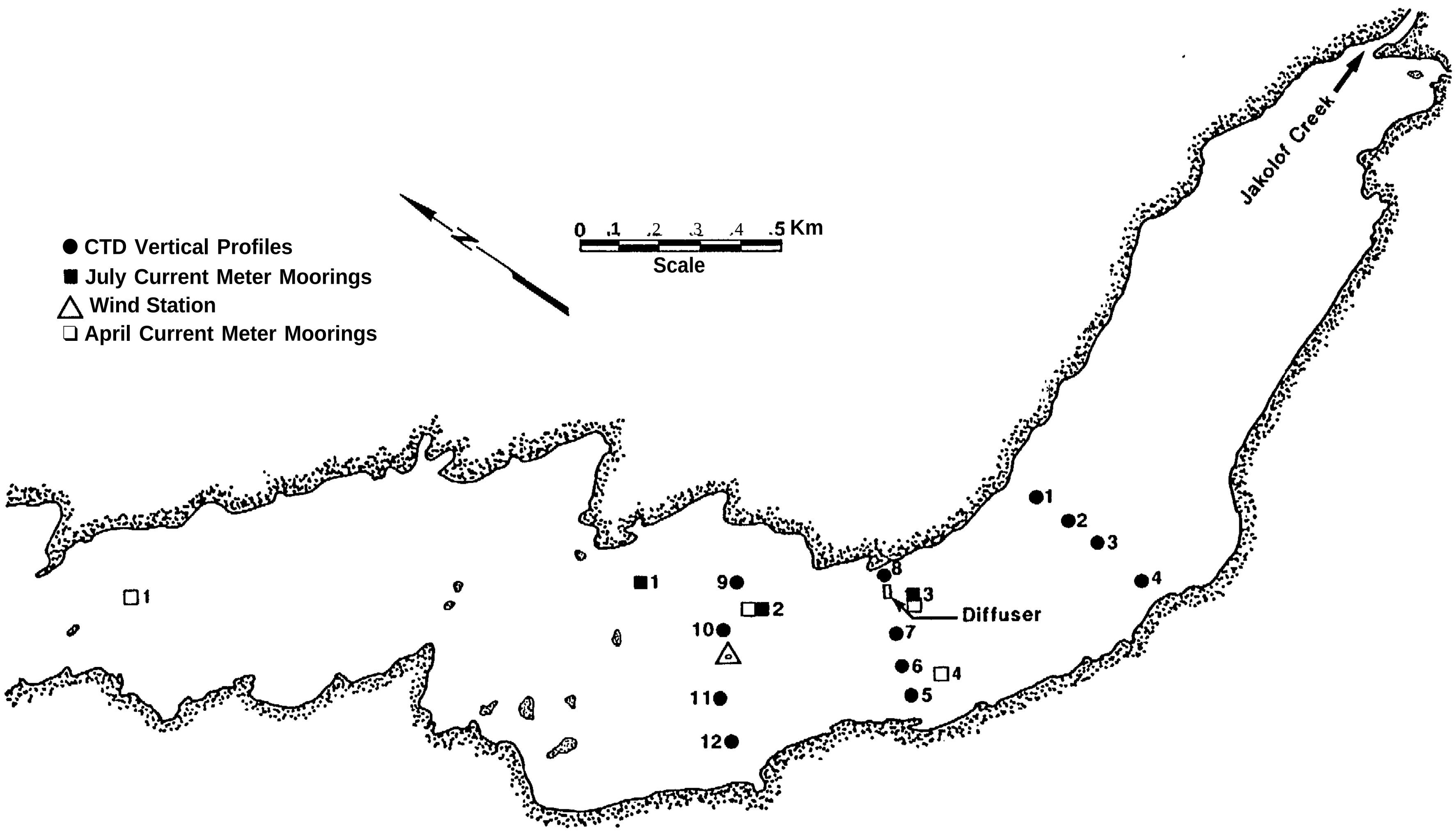
Vicinity Map of Kachemak Bay Showing
Location of Jakolof Bay Study Area
Dames & Moore

Job No. 06797-029

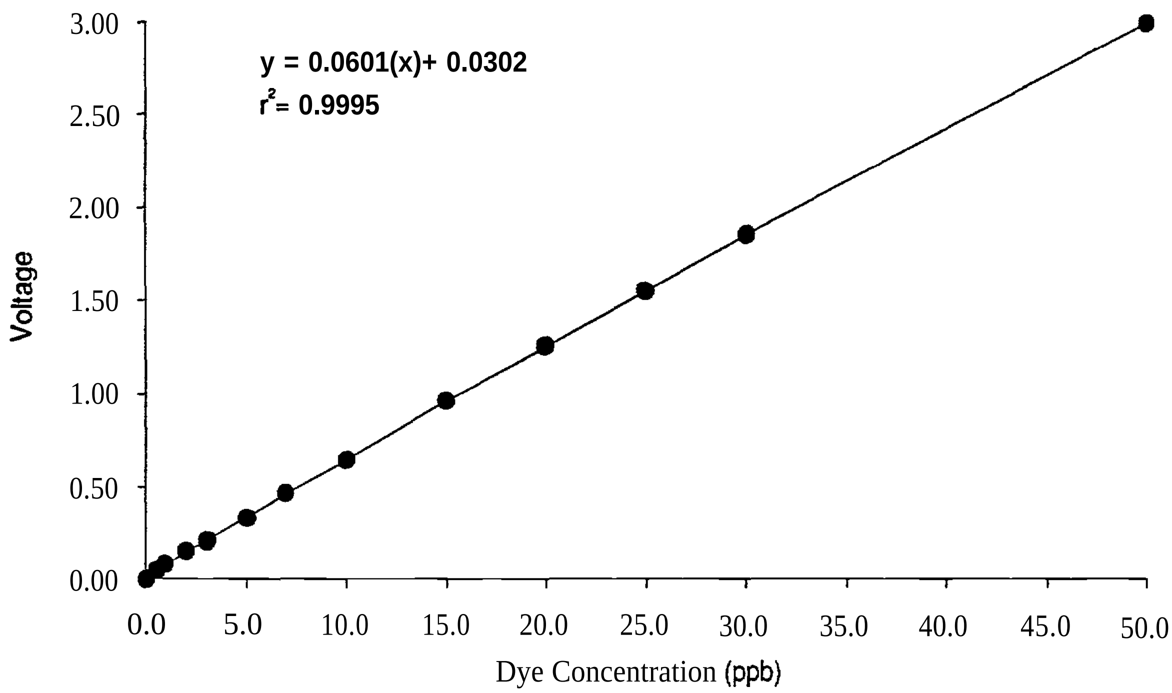
Figure 2-1



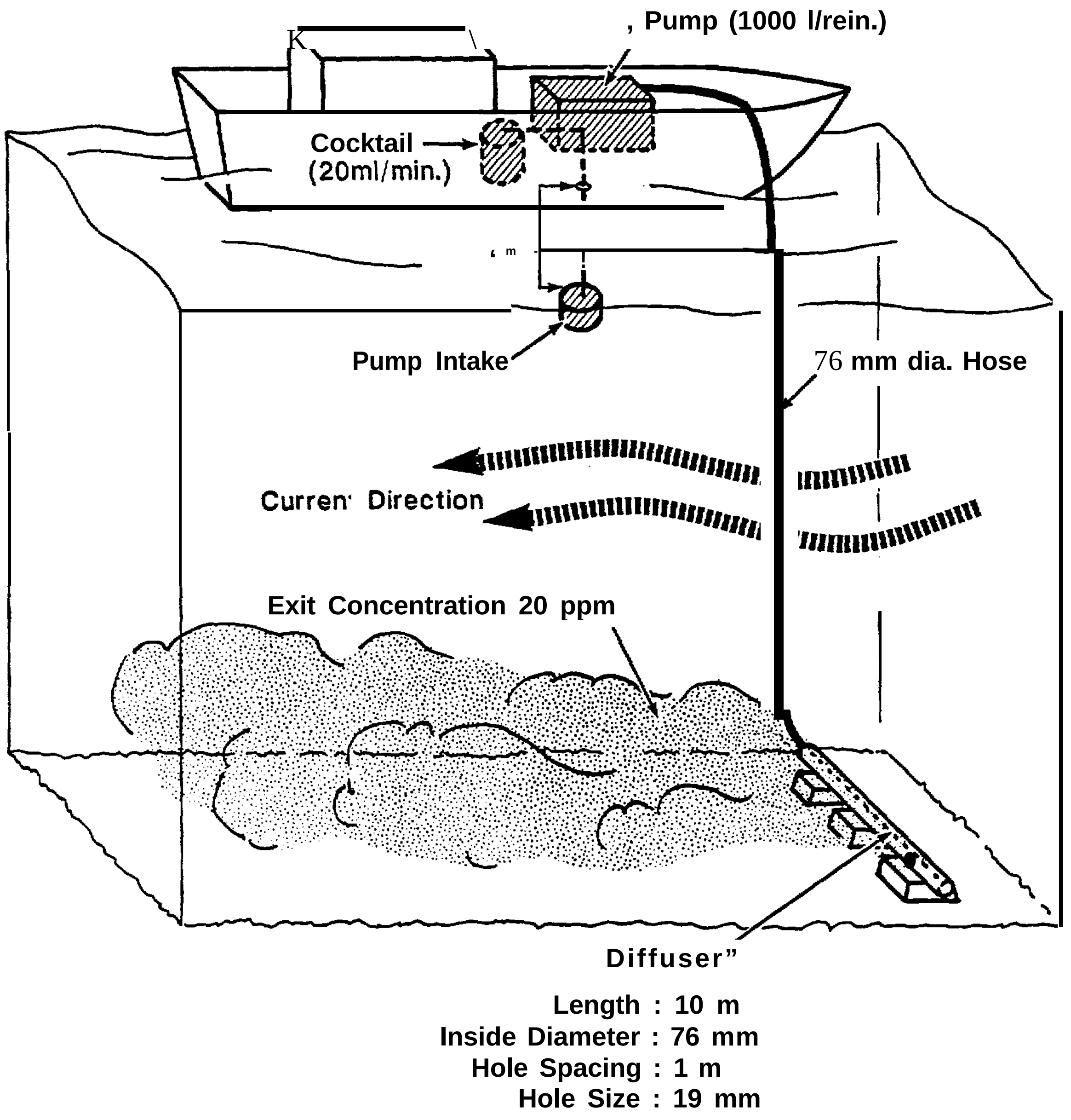
Fish Holding and Fish Tracking Stations in Jakolof Bay
Figure 2-2



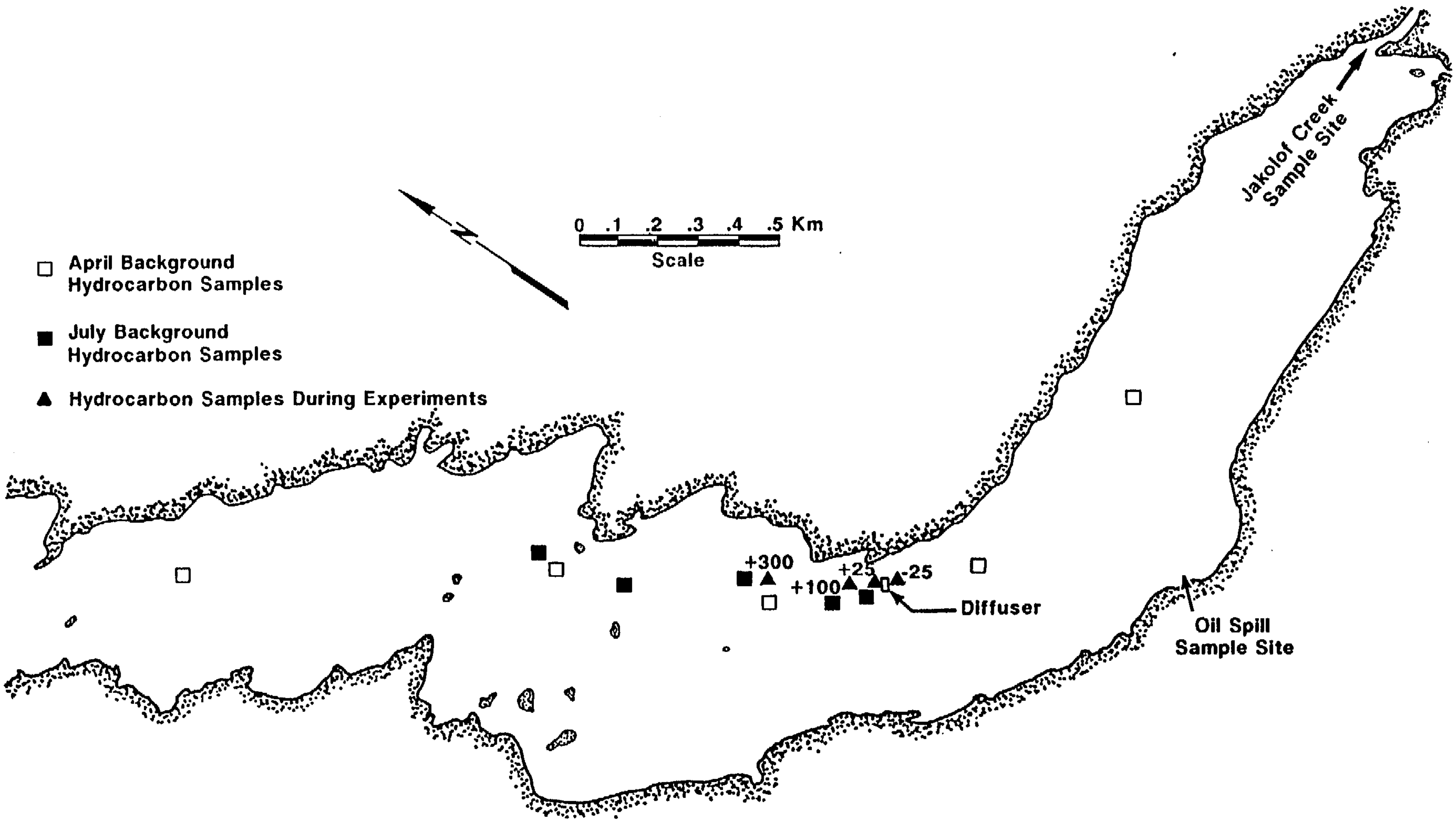
Oceanography and Water Property Stations in Jakolof Bay
Figure 2-3



Regression of Fluorometer Voltage and Dye Concentration
Figure 2-4



Hydrocarbon Injection System
Figure 2-5



Hydrocarbon Sample Stations in Jakolof Bay
Figure 2-6

3.0 RESULTS

3.1 OCEANOGRAPHIC CONDITIONS

3.1.1 General Oceanography

Jakolof Bay can be characterized as a very dynamic oceanographic environment due to the combined influences of large semi-diurnal tides and shallow bathymetry. Tidal ranges of up to 8 m are encountered. The bay is approximately 3 km long and 0.5 km wide with average mllw depths less than 3 m over the upper half of the bay and less than 6 m elsewhere. The shallow depths and large tides yield tidal currents of UP to 2 knots near the mouth of the bay. Currents are generally less than 3/4 knots in the upper half of the bay. The very shallow depths at the head of the bay result in extensive areas of exposed muds flats during low tides.

A large tidal prism and strong currents generally result in well-mixed conditions and small density gradients. The presence of fresh water from Jakolof Creek can be seen in the upper meter of water, particularly during neap ebb tides. The presence of a fresh water layer is most noticeable in the center of the bay. Radiant heating of surface water contributes to density gradients in the upper meter, particularly in summer conditions.

Winds in the summertime are typified by down slope winds caused by the glaciers to the south east of the bay. These winds flow north-westerly along the axis of the bay and reach speeds of 15 to 20 knots. Conducting tracking experiments was impractical during the latter conditions.

Currents in the bay are principally bidirectional in response to tidal forcing and the long, narrow shape of the bay. Some eddies occur behind the islands on both flood and ebb tides and during extreme neap conditions. A comparison of the tides and currents recorded near the mouth of the bay during the reconnaissance survey is shown in Figure 3-1. As can be seen the currents are strongly bimodal. The weaker outgoing velocities can be attributed to the larger cross-sectional area during flood tide and hence lower velocities during ebb conditions.

3.1.2 Oceanographic Conditions During Experiments

Tide levels during the study period (July 11 to 20th) and during each experiment (bold lines on plot) are shown in Figure 3-2. All experiments took place on ebb tides with the treatment experiments following the control experiments on the same phase of the tide on the following day. A minimum period between treatments of 2.5 days (i.e., 5 tidal cycles) was scheduled to allow flushing of the hydrocarbon solution from the previous experiment. During spring tides it was calculated that two to three tidal cycles were required to flush the oil contaminated waters, while during neap tides the required flushing time increased to five to six cycles.

The tides and currents recorded 1.5 m from the bottom at station 3 near the diffuser site are shown in Figure 3-3. Maximum ebb currents during the three treatment experiments were 0.12m/s, 0.07m/s, and O. 19m/s, respectively. Figure 3-4 shows the water temperature and salinity recorded from the same meter array. Temperature changes of 1 "C and salinity changes of over 1 ppt occur during the tidal cycle. The consistent large spikes in salinity are attributed to the influence of fresh water from Jakolof Creek.

3.2 HYDROCARBON CONCENTRATIONS

3.2.1 Background Conditions

Water samples were collected prior to experimental discharge of the cocktail in order to evaluate the background concentration of hydrocarbons in Jakolof Bay. The sum of individual hydrocarbons C_5 to C_{10} in the samples is given in Table 3-1. Background concentrations in April and July ranged 0.00 to 1.27 ppb and 0.52 to 1.66 ppb, respectively. Toluene was the main component of all the samples except sample No. 3, which contained mainly octanes/cycloheptanes (see Appendix E). Concentrations of hydrocarbons in samples taken during control no. 1 (nos. 11 and 12) were 2.20 ppb and 1.02 ppb (Table 3-1). The hydrocarbon components of sample no. 11 were benzene and toluene, whereas sample no. 12 contained only toluene.

The presence of toluene in the background water samples and the increase in total hydrocarbon concentration between April and May suggests the background hydrocarbons may be coming from anthropogenic sources. In order to answer this question, an analysis of the hydrocarbon composition of gasoline at various dilutions was performed in the laboratory. The results showed that a minute amount of gasoline can contaminate a large volume of water with a number of the cocktail hydrocarbons including benzene, toluene, and xylenes (Appendix F). At extreme dilutions, 770 times the original volume, only benzene, toluene, and m-, p-xylene were measurable. Further dilutions would have probably reduced the number of detectable hydrocarbons to only one or two (i.e., benzene and toluene).

Outboard motors discharge varying amounts of unburned gasoline into water, which is visually observable in calm water behind a boat. Jakolof Bay receives a fair amount of boat traffic during the summer from sport fishermen an recreation boaters. Toluene, which was the most persistent hydrocarbon in the gasoline analysis, was present in all of the July samples and in one of the April samples. For this reason, it is believed that the main contributors to the general background concentration of hydrocarbons in the water column are due to unburned fuel from boat exhaust.

Table 3-1. Total hydrocarbon concentration in Jakolof Bay water samples during background, control, and treatment conditions. Concentrations are the sum of individual cocktail hydrocarbons less C_1-C_4 in $\mu g/L$ (ppb).

Sample Concentration No.	Experiment	Date	(ADT)[a]	Elapsed Time (rein)	time[b] location	Sample (m)	Depth (ppb)
1	Background	4/12/88	09:20	--	c	2	1.10
2	"	"	0940	--	c	3	0.16
3	"	"	09:55	--	c	3	1.27
4	"	"	10:05	--	c	3	0.00
5	"	"	10:25	--	c	2	0.00
6	Background	7/14/88	09:42	--	c	1	0.77
7	"	"	09:45	--	c	1	1.66
8	"	"	09:45	--	c	1	0.52
9	"	"	09:50	--	c	1	0.73
10	"	"	10:00	--	c	1	0.67
11	Control 1	7/19/88	20:10	--	c	3	2.20
12	"	"	21:00	--	c	3	1.02
13	Treatment 1	7/20/88	21:30	0	-25e	4	0.00
14	"	"	21:30	0	-25	1	1.32
15	"	"	21:55	+25	+25	4	57.02
16	"	"	21:55	+25	+25	1	1.59
17	"	"	22:15	+45	+100	4	3.16
18	"	"	22:15	+45	+100	2	2.84
19	"	"	22:35	+65	-25	4	0.75
20	"	"	22:35	+65	-25	1	d
21	"	"	22:55	+85	+100	4	14.93
22	"	"	22.55	+85	+100	2	1.20
23	"	"	23:15	+105	+300	4	43.78
24	"	"	23:15	+105	+300	2	1.53
25	"	"	23:15	+105	+100L[f]	4	d
26	"	"	23:15	+105	+1OOL	2	8.58
27(1)	Background	7/21/88	1227	--	c	0.3	0.00

--CONTINUED--

[a] Alaska Daylight Savings Times.
[b] Elapsed time after start of diffuser pump.
[c] See Figure 2-6.
[d] Sample lost.
[e] Distance (m) upbay (-) or downbay (+) from the diffuser, see Figure 2-6.
[e] Sample from 25 to 50m lateral of station.

Table 3-1, Continued

Sample Concentration No.	Experiment	Date	(ADT)	Elapsed Time (rein)	time[b] location	Sample (m)	Depth (ppb)
27(2)	Control 2	7/23/88	21:05	-25	-25	4	0.00
28	"	n	21:40	+10	+100	2	d
29	n	"	21:40	+10	+100	4	d
30	"	"	21:50	+20	-25	2	d
31	"	"	21:50	+20	-25	4	0.00
32	"	"	2210	+40	+100	2	d
33	w	"	2210	+40	+100	4	0.00
34	"	"	23:10	+60	+300	2	d
35	"	"	23:10	+60	+300	4	d
36	"	"	13:30	0	+100	2	0.96
37	n	"	13:30	0	+100	4	1.15
38	"	"	13:50	+20	-25	1	0.00
39	"	"	13:50	+20	-25	4	1.43
40	"	"	14:30	+40	+100	2	0.00
41	"	"	1430	+40	+100	4	0.00
42	"	"	14:50	+60	+300	2	0.00
43	"	"	14:50	+60	+300	4	0.00
44	Treatment 2	7/25/88	13:30	0	-25	1	0.00
45	"	0	13:30	0	-25	4	1.01
46	"	"	14:15	+45	+25	2	0.00
47	"	"	14:15	+45	+25	4	64.91
48	"	"	15:00	+90	+100	2	2.52
49	"	"	15:00	+90	+100	4	0.97
50	"	"	15:20	+110	-25	1	2.35
51	"	"	15:20	+110	-25	4	0.67
52	"	"	15:40	+130	+100	2	2.01
53	"	"	15:40	+130	+100	4	0.48
54	"	"	16:00	+150	+300	2	0.81
55	"	"	16:00	+150	+300	4	0.92
56	"	"	15:00	+90	+1OOL	4	53.48
57	"	"	I 5:40	+130	100L	4	9.99
58	Background	7/27/88	15:00	--	c	0.3	49.49
59	"	"	15:00	--	c	0.3	30.10
60	Control 3	7/28/88	16:35	0	-25	1	0.00
61	"	"	16:35	0	-25	4	6.82
62	"	"	17:00	+25	+25	2	0.00
63	"	"	17:00	+25	+25	4	0.00
64	"	"	17:00	+25	+25	4	0.76
65	"	"	17:00	+25	+25	4	0.88
66	"	"	17:40	+40	+100	2	0.59
67	"	"	17:40	+40	+100	4	0.00
68	"	"	17:40	+40	+100	4	0.91
69	"	"	17:40	+40	+100	4	0.00
70	"	"	18:00	+60	+300	2	0.00
71	"	"	18:00	+60	+300	4	1.81

Table 3-1, Concluded

Sample Concentration No.	Experiment	Date	(ADT)	Elapsed Time (rein)	time[b] location	Sample (m)	Depth (ppb)
72	Treatment 3	7/29/88	16:30	0	-25	1	0.98
73	"	"	16:30	0	-25	4	1.93
74	"	"	16:30	0	+25	4	1.50
75	"	"	1630	0	+25	4	0.93
76	"	W	1655	+25	+50	2	0.57
77	"	"	16:55	+25	+50	4	3.76
78	"	"	17:15	+45	+100	2	1.16
79	"	"	17:15	+45	+100	4	0.61
80	"	"	17:35	+65	-25	1	1.09
81	"	"	17:35	+65	-25	4	1.49
82	"	"	17:55	+85	+25	2	0.00
83	"	"	17:55	+85	+25	4	21.85
84	"	"	17:55	+85	+25	4	24.60
85	"	"	17:55	+85	+25	4	7.59
86	"	"	18:15	+105	+100	2	0.60
87	"	"	18:15	+105	+100	4	5.68
88	"	"	18:15	+105	+100	4	6.85
89	"	"	18:15	+105	+100	4	5.68
90	"	"	18:35	+125	+300	2	2.14
91	"	"	18:35	+125	+300	4	4.16
92	"	"	18:35	+125	+300	4	4.61
93	“	"	18:35	+125	+300	4	1.44

The issue of background hydrocarbons in Jakolof Bay waters was further complicated by an oil spill from a tug and barge operation in the area. The spill occurred on July 17 near the upper south side of the bay (Figure 2-6). In order to evaluate the effects of this spill on water quality, a number of samples were collected on July 18 and 19 for background check, and on July 19 during control 1. These samples were processed by solvent extraction and subsequent GC analysis (Appendix B). The concentration of cocktail hydrocarbons in these samples could not be quantified because they are volatilized and lost during the analysis (see Appendix B). However, based on qualitative comparison of chromatograms of these background samples with chromatograms of samples collected at the spill site, it was concluded that the contribution of the spill to background hydrocarbons was minimal, if anything at all. An investigation of the spill by Payne et al. (1988) found that dispersed oil droplets and dissolved components were present along shore at the spill site on July 18. But, samples collected at 2 m deep from near the diffuser on the same day indicated no evidence of dispersed oil. The low concentrations (i.e., 2.2 ppb) measured at 3 m deep during the control experiment on July 19 (Table 3-1), also indicates no significant subsurface contamination.

3.2.2 Conditions During Experimental Discharge

The concentration of hydrocarbons in all samples from the control experiments, except for one sample, ranged from 0.00 to 2.20 ppb (Table 3-1). Toluene was the only detectable hydrocarbon in all samples except for sample No. 11, which also contained benzene (Appendix F). The one exception, sample No. 61, contained 6.82 ppb of toluene. This large difference may be due to contamination, since this sample was taken up bay from the diffuser and was the only sample out of a total of 31 samples collected during the control runs to show a high concentration. The source of contamination may have been from the out board motor on the sample vessel. An analysis of variance test of hydrocarbon concentrations among the background samples and the control samples (i.e., samples 1 to 12, 27 to 43, and 60 to 71, Table 3-1) found no significant difference (P = 0.4 1) among sample periods (Appendix G). These results indicate that the treatment experiments and the oil spill did not increase the background hydrocarbon levels.

The concentration of total hydrocarbons in the treatment samples ranged from 0.00 to 64.91 ppb. The highest concentrations were measured from samples taken at 4 m deep at station +25 m. The concentrations at this station for treatments 1 and 2 were 57.02 and 64.91 ppb, respectively. During treatment 3, three deep water samples were collected at this station and the concentrations ranged from 7.59 to 24.60 ppb. In contrast, the highest concentration measured from samples taken near the surface (i.e., 1 to 2 m deep) was 2.84 ppb. Total hydrocarbon concentrations of the surface samples were generally lower than concentrations of the bottom samples. This indicates the hydrocarbon plume was not completely mixed from the surface to the bottom. Because of the limited number of samples collected during the experiment, it was not possible to detect if a concentration gradient was established downstream from the diffuser.

Toluene was the main or the only component detected in treatment samples with low hydrocarbon concentrations. In treatment samples with relatively high concentration, the main components were toluene and benzene, followed by n-pentane, isopentane, and xylenes. Occasionally, trace amounts of other cocktail hydrocarbons were observed in the samples.

During the course of treatment experiments, three additional background water samples (i.e., sample Nos. 27(1), 58, and 59) were collected from the mouth of Jakolof Creek. Sample No. 27(1), collected on July 21, showed 0.00 ppb hydrocarbon concentration, whereas sample Nos. 58 and 59, collected on July 27, contained 49.49 ppb and 30.10 ppb hydrocarbons, respective y. The large difference between sample No. 27(1) and sample Nos 58 and 59, which were collected 1 and 2 days following a treatment, respectively, suggests the latter samples were contaminated. The source of contamination may have been from the sample boat, which was anchored less than 10 m from the sampling site.

3.3 PLUME STUDIES

The finite-difference grid used in the far-field model studies is shown in Figure 3-5. The greatest grid resolution centers on the region of the diffuser. In order to minimize numerical dispersion and to reduce the amount of computer storage needed, the model grid was oriented parallel to the long axis of Jakolof Bay (the grid axis is 56.56 degrees west of north). The grid resolution is finest in the region of the diffuser where cell sizes are 12.5 m long. Grid resolution increases to 100 m at the mouth of the bay and 200 m at the head of the bay. A total of 50 cells in the bay axis direction and 34 cells in the cross bay direction were used.

3.3.1 Model Calibration

Before the models were used in a predictive mode, they were each calibrated to known conditions in Jakolof Bay. The hydrodynamic model was calibrated using the current and tide data recorded during the reconnaissance survey. The water quality model was calibrated using the results of the rhodamine dye studies. Model calibration is required to confirm or obtain values for the empirical parameters used in the modeling. Specifically, these parameters are the friction coefficient in the hydrodynamic model and the dispersion coefficient in the water quality model. While typical values have been published in the literature, the range of such parameters is usually a few orders of magnitude. Calibration studies are therefore required to obtain the best fit of these parameters for the unique conditions in Jakolof Bay.

3.3.1.1 Hydrodynamic Model

During the initial calibration of the hydrodynamic model, runs were made using both current and tidal boundary conditions at the mouth of Jakolof Bay. The model grid initially only extended as far as the mllw line. Satisfactory calibration could not be achieved using the full range of friction coefficients from 0.1 to 0.001 and the predicted currents at current meter station 2 (Figure 2-3) were 50% below the recorded currents. The model grid was then extended to include the intertidal area at the head of the bay (see Figure 3-5), adding approximately 25% to the surface area of the model. This modification resulted in dramatic improvement to the hydrodynamic calibration and indicated the importance of the intertidal area in driving the currents at the head of the bay. Sensitivity studies indicated a friction coefficients of 0.007 gave the best calibrations.

A 20 second timestep was used in the simulations because sensitivity studies with 60, 30,20 and 10 second timesteps indicated a 20 second timestep was required for the spring tide conditions. The high sensitivity of the model under these conditions is due to the rapid propagation of changes in water level in regions of shallow bathymetry and small cell sizes, and the reasonably complex topology.

A comparison of the predicted and measured currents near the mouth of the bay (i.e., station 1) under neap and spring tide conditions are shown in Figure 3-6. As can be seen, the predicted currents are very close to the measured currents except during the ebb tides. These high predictions are due to the change in cross-sectional area of the bay, which occurs during flooding and is not included in the model. While flooding could have been included, computational times are increased by an order of magnitude. The additional expense was not felt to be justified given the generally good calibration. The predicted and actual currents for station 2 are shown in Figure 3-7. The predicted and actual tides inside the bay are almost exact since tides at the mouth of the bay were used to drive the model, There is very little tidal phase shift within the 3-km length of Jakolof Bay.

3.3.1.2 Water Quality Model

The water quality model was calibrated using the results of a rhodamine dye study. Rhodamine dye at a concentration of 1.76 g/L (1.0 L of 20% dye in a 114 L bucket) was introduced into the cliff user at a rate of 1260 ml/min resulting in a discharge concentration of approximately 2345 ppb. A plot of the resulting plume, based on hand recorded data, is shown in Figure 3-8. Data collected by an auto-logger was not usable due an equipment malfunction.

In order to obtain a starting point for the numerical calibration of the water quality model an approximate value was obtained assuming a steady state two-dimensional Gaussian model for the centerline concentrations. The equation for the centerline equation was recast in the form;

$$c = K^{-0.5}(D)\,x$$

where;

c = centerline concentration,
K = constant including discharge rate,
D = dispersion coefficient,
x = downstream distance.

Fitting a one-parameter regression model to the centerline concentrations from Figure 3-8 yielded an approximate dispersion coefficient of 0.09 m^2/sec. This is a low value (Fischer et al. 1979) indicating smooth bottom conditions and hence low turbulence. This finding is consistent with subsurface (divers) and surface observations, which indicate Jakolof Bay has a smooth bottom with a covering of kelp, and the observed absence of surface boiling during the maximum ebb tides.

The water quality model was run using two orders of magnitude of dispersion coefficients approximately centered on the 0.09 value (O. 1 to 0.001). A value of 0.001 gave the best fit in terms of the width of the plume; however, the predicted centerline concentrations near the diffuser were approximately 50°% low. During the dye studies, it was noted that the plume consistently remained in the bottom 2 meters of water, which is the lower half of the water column. Also, the results of the hydrocarbon sampling indicated concentrations were greater near the bottom. To account for these observation, the discharge concentrations in the model were doubled causing the predicted width and concentrations to match the actual dimensions fairly well. The predicted concentrations are shown in Figure 3-9. Note, that the measured concentrations shown in Figure 3-8 were recorded over a period of two hours, which may explain the counter intuitive widening of the IO ppb contour in that figure. Figure 3-9, on the other hand, is a snap-shot of the plume 1 hour into the simulation.

3.3.2 Model Estimates of Hydrocarbon Distribution Concentration

The far-field model was run to predict hydrocarbon concentrations for each of the three treatment experiments. Note, that the control experiments were conducted at the same phase of the tidal cycle as the treatment experiments, but on the previous day, in order to match the oceanographic conditions as closely as possible. Table 3-2 shows a comparison of the tidal ranges during the control and treatment experiments.

Table 3-2: Tidal Ranges During Experiments

Experiment	Date	Tides (m) High	Low	Range
Control 1	7/19/88	5.0	1.2	3.8
Treatment 1	7/20/88	4.9	1.3	3.6
Control 2	7/24/88	3.7	2.3	1.4
Treatment 2	7/25/88	4.0	2.2	1.8
Control 3	7/28/88	5.5	0.8	4.7
Treatment 3	7/29/88	5.8	0.4	5.4

Predictions of hydrocarbon concentration were made using the NOS tides for Seldovia as boundary conditions and the actual hydrocarbon release rates as recorded during the experiments (Table 3-3). The time and height differences in the tides between Seldovia and Jakolof Bay are negligible (less than 1 minute and 3 cm respectively).

Table 3-3. Seawater pumping rates and cocktail injection rates during treatment experiments.

Experiment	Date	Start Time (ADT)[a]	Stop Time (ADT)[a]	Pumping Rate (L/rein)	Cocktail Injection rate (ml/min)
Treatment 1	7/20/88	21:29	23:52	946[b]	25
Treatment 2	7/25/88	13:30	17:12	946	30-40
Treatment 3	7/29/88	16:30	19:46	946	15-21

[a] Alaska Daylight Savings Time.
[b] At 23:13 the anchorline on the stern broke allowing the boat to swing, which caused the pumping rate to vary from 757 to 946 L/rein during remainder of experiment.

3.3.2.1 Treatment 1

High slack tide, before the experiment on July 20, occurred at 19:28. Table 3-2 indicates the 3.6 m tidal range was representative of an intermediate or average tide. The diffuser was turned on two hours after high tide at 21:29 and discharged 25 ml/min of hydrocarbon cocktail into a seawater flow of 946 L/rein until 23:52. Salmon were released from the holding pen approximately 2.75 hours after high tide and were tracked for approximately 1.75 hours (i.e., from 22:13 to 23:58).

A vector plot of the currents in the central portion of the bay 3.5 hours into the ebb tide is shown in Figure 3-10. Note the slight ebby in the inlet northwest of the diffuser and the reduction in flow velocity behind the islands. The predicted current speeds at the diffuser were within 59'0 of the measured currents. The maximum current at the diffuser site during the experiment {i.e., maximum ebb flow) was approximately 0.15 m/s.

The predicted plume position and hydrocarbon concentrations in the water column at half-hour intervals, starting 0.5 hours after the diffuser was turned on, are shown in Figure 3-11. Each figure shows the 10, 5, 1 and 0.5 ppb isolines. The 1 O ppb contour defines the center of the plume and the 0.5 ppb contour the outer edge of the plume in each case. These concentrations assume a 0.0 ppb background concentration. Therefore, the actual concentration of Cl to C_{10} hydrocarbons may be 1 to 2 ppb greater (see Section 3.2.1 for background levels) than the predicted concentrations depending on background hydrocarbon levels at the time of treatment. Predicted hydrocarbon concentrations less than 0.5 ppb are not identified because the level of error, depending on background levels, may range from O to 2 ppb.

3.3.2.2 Treatment 2

High slack tide before the treatment experiment on July 25 occurred at 13:03. Neap tide conditions occurred on this day with a tidal range of 1.8 m (Table 3-2). The diffuser was started 0.5 hours after high tide at 13:30 and discharged 30 to 40 ml/min of hydrocarbon cocktail into a seawater flow of 946 L/rein until 17:12. The variable discharge rate was due to problems encountered with the vacuum feed to the pump. However, detailed notes of the pumping rate were recorded and used in the simulation. Salmon were released two hours after high tide and tracking occurred for approximately 2.25 hours (i.e., from 14:59 to 17:15).

The predicted plume position and concentrations at half-hour intervals, starting 0.5 hours after the diffuser was turned on, are shown in Figure 3-12. The slow growth of the plume is a result of the neap tide conditions. Maximum currents of 0.07 m/s at the diffuser during the ebb flow were considerably less than in treatment 1.

3.3.2.3 Treatment 3

The tidal range during treatment 3 (i.e., 5.4 m on July 29) was near the maximum range for Jakolof Bay. High slack tide before the treatment experiment occurred at 15:59. The diffuser was turned on 0.5 hours after high tide at 16:30 and discharged from 15 to 21 ml/min of hydrocarbon cocktail into a seawater flow of 946 L/rein until 19:46. The variable discharge rate was due to problems with a valve adjustment on the vacuum feed to the pump. Salmon were released 1.5 hours after high tide and tracking occurred for approximately 2.25 hours (i.e., from 17:33 to 19:46).

The predicted hydrocarbon concentrations during treatment 3 are shown in Figure 3-13. The rapid rate of plume expansion during this experiment is a result of the spring tide conditions and is 25% to 35% faster than during the neap tide conditions of treatment 2. The maximum current during the experiment at the diffuser site was 0.20 m/s. Note, that between 18:30 and 19:00 (Figure 3-13) the area within the 10 ppb isoline contracts, but the area within other isolines continues to grow. This reduction of the 10 ppb contour is due to the enhanced mixing and hence dispersion under high current conditions. The opposite effect can be seen in Treatment 2 under low flow conditions (Figure 3-12 at 15:30), where the area within the 10 ppb isoline makes up 50% of the total plume.

3.4 SALMON MOVEMENT BEHAVIOR

3.4.1 Movement Patterns During No-Discharge Conditions

All but one of the 38 pink salmon released during the three control experiments headed back toward the home stream. One fish from control 2 headed out of the study area immediately after release and was not identified during the remainder of the tracking period. The return route back toward the home stream was similar for all fish within an experiment but differed among experiments. Fish from control 1 all headed up bay immediately after release from the holding pen (e.g., Figure 3-14 and Appendix H, which show fish positions at specific times relative to the cliff user indicated by the 10 isoline). They generally moved along an arc shaped route that first headed south-south west, turned southeast, and passed within 100 m of the diffuser. The return route for fish from control 2 was not as direct as fish from control 1. Control 2 fish headed across the bay in a westerly direction, at the center of the bay they turned rather sharply to the southeast, and headed up bay passing within 25 to 150 m of the diffuser (e.g., Figure 3-15 and Appendix H). Fish from control 3 returned toward the home stream along the most indirect route of the three experiments (e.g., Figure 3-16 and Appendix H). The return route was characterized by: movement up bay (south) for several hundred meters immediately after release, a sharp turn to the west followed by movement either across the bay or down bay, continued movement toward the west shore and eventually out of tracking range. After a period ranging 12 to 30 minutes, the fish returned to the center of the bay, turned sharply to the southeast, and headed up bay passing within 100 m and in some cases directly over the diffuser. Horizontal movement patterns from all three experiments were generally directed up bay against the ebb tide (positive rheotaxis) with short periods of movement either across or with the current (negative rheotaxis).

The duration-of-return from the time of release at the fish pen to the time of passing the diffuser was substantially different among the three experiments (Table 3-4). The return time for control 1 was the shortest (mean 26.4 minutes) and the return time for control 3 was the longest (mean 65.8 minutes).

Fish that moved toward the home stream exhibited two types of vertical movement patterns. Following an initial dive to 3 to 4 m, the fish moved up and down in the water column over a depth range from 2 to 4 m during their return to the home stream. The amplitude of this vertical movement, however, varied among and within the experiments. During control 1, most fish exhibited a small-amplitude (<0.5 m) vertical movement that continued for the entire return period (e.g., Figure 3-17). During controls 2 and 3, most fish initially exhibit several large-amplitude (1 to 2 m) vertical movements followed by smaller amplitude movements near the end of the return period (e.g., Figures 3-18 and 3-19). The occurrence of the small-amplitude versus the large-amplitude patterns appears to be related to the horizontal movements during the return toward the home stream. When the fish returned along a more direct route, during control 1, they only exhibit small-amplitude vertical movements. But, when the fish returned along a more indirect route, during controls 2 and 3, they exhibited both large- and small-amplitude vertical movements. Large-amplitude movements occurred at a higher frequency during the period when the fish were moving either across the bay or down bay. When the fish were headed along a straight horizontal course toward the home stream, the amplitude of the vertical movements decreased.

Table 3-4. Duration of fish return period and fish depth during control experiments.

Experiment	Number of Fish[a]	Duration[b] (min.)		Depth[c] (m)	
		Mean	95% C.I.[d]	Mean	95% C.I.
Control 1	10	26.4	20.1 to 32.6	3.68	3.62 to 3.73
Control 2	9	49.0	43.8 to 54.1	4.01	3.97 to 4.06
Control 3	18	65.8	57.5 to 74.1	3.00	2.96 to 3.04

[a] Only includes fish tracked toward the home stream.
[b] Period from time of fish release to time of movement past disffuser.
[c] Only includes depths during period of straight horizontal movement toward the home stream.
[d] Confidence interval.

The swimming speed of the fish during the return period also varied in association with the horizontal and vertical movement patterns (Figures 3-17 to 3-19). The fish swam slower (mean ground speed ranging 0.22 to 0.36 m/s) during periods of movement either across bay or down bay and during periods of large-amplitude vertical movements (Table 3-5). The fish swam faster (mean ground speed ranging 0.34 to 0.55 m/s) during periods of straight horizontal movements up bay and during periods of small-amplitude vertical movements. The maximum ground speeds during the latter phase ranged up to 1.6 m/s (Table 3-5).

Table 3-5: Swimming speeds (ground speed m/s) of fish during control experiments.[a]

Experiment	Mean	Minimum	Maximum	95% C.I.[d]
		Initial Speed[b]		
Control 1	0.36	0.48	0.69	0.33 to 0.39
Control 2	0.22	0.10	0.44	0.20 to 0.23
Control 3	0.26	0.00	1.23	0.25 to 0.27
All	0.26			
		Final Speed[c]		
Control 1	0.49	0.51	1.23	0.45 to 0.53
Control 2	0.34	0.00	0.79	0.32 to 0.35
Control 3	0.55	0.07	1.61	0.53 to 0.58
All	0.46			

[a] Only includes fish tracked toward the home stream
[b] Only includes data during period when fish are not headed toward the home stream.
[c] Only includes data during period of straight horizontal movement toward the home stream.
[d] Confidence interval.

The average depth of fish during the period of straight horizontal movement toward the home stream was variable among experiments and was associated with the interface between lower salinity surface waters and higher salinity bottom waters. The depth of fish during the final portion of the return period varied little within an experiment but was significantly different ($P < 0.001$) among experiments (Table 3-4 and Appendix G). During controls 2 and 3, the fish headed back toward the home stream at mean depths of 4 and 3 m, respectively. Vertical salinity profiles along the return route (Figures 3-20 and 3-21) indicate that the fish were moving along the interface between the low salinity surface waters and the higher salinity bottom waters. Comparisons of fish depth with hydrographic conditions for control 1 were not possible because vertical profiles of salinity were not taken along the return route.

The movement activity of salmon during the controls indicates two types of movement behavior occur during the return to the home stream. Salmon that returned toward the home stream in the least time were apparently capable of orienting to the home stream very soon after their release. This active movement toward the home stream was characterized by relatively straight horizontal movements against the current (positive rheotaxis), small-amplitude vertical movements with occasional large-amplitude movements, and high swim speed. Salmon that required more time before returning toward the home stream spent more time searching. This searching behavior was characterized by horizontal movements across the current or with the current (negative rheotaxis), a higher frequency of large-amplitude vertical movements, and a low swim speed.

3.4.2 Movement Patterns During Discharge Conditions

Two of the three treatment experiments (i.e., treatments 1 and 2) did not result in a test of fish exposure to oil because the hydrocarbon plume did not intercept the homing fish, except for one case. During treatment 1, six of the ten fish released headed west, across the bay, and moved out of tracking range within 13 to 20 minutes after release (Appendix I). A plot of fish 19 (Figure 3-22), which is typical of this group, shows these fish moved across the bay before the plume reached this area. A survey of the southwestern shore of the bay with a mobil hydrophore after the experiment detected some of these fish in the upper bay, beyond the diffuser. Three other fish followed a similar route, but instead of continuing across the bay, they turned southwest and headed toward the home stream along a route well outside of the plume (e.g., Figure 3-23). These fish also moved too fast to be entrained by the plume. Only fish no. 14, which stopped moving for 55 minutes near the center of the bay, became entrained by the edge of the plume (Figure 3-24). During treatment 2, all of the fish, except one, either moved across the bay out of tracking range (e.g., Figure 3-25) or moved up bay along routes similar to treatment 1 and did not encounter the plume (e.g., Figure 3-26). One fish headed out of the bay ahead of the plume (Figure 3-27). Vertical movements of fish during both treatments were similar to those observed during the control experiments.

The duration-of-return period and fish depth for fish that headed toward the home stream were similar between treatments 1 and 2 (Table 3-6). The average duration-of-return was approximately 40 minutes and the average depth was approximately 3.5 m. A comparison of the duration-of-return period between treatment and control experiment pairs (e.g., treatment 1 versus control 1) indicates no significant difference ($P > 0.05$) for both groups (Appendix G). A test of fish depth indicates no significant ($P > 0.05$) difference between treatment 1 and control 1, but control 2 fish were significantly ($P < 0.05$) deeper than treatment 2 fish (see Tables 3-4 and 3-6). The depth of the latter treatment (i.e., 3.42 m), however, was closely associated with the interface of the vertical salinity gradient (Figure 3-28) as was observed for the control experiments.

Table 3-6. Duration of fish return period and fish depth during treatment experiments.

Experiment	Number of Fish[a]	Duration[b] (min.)		Depth[c] (m)	
		Mean	95% C.I.[d]	Mean	95% C.I.
Treatment 1	4	39.7	-29.9 to 109.4	3.67	3.60 to 3.75
Treatment 2	5	43.6	-9.9 to 97.1	3.42	3.27 to 3.58
Treatment 3	18	118.5	115.8 to 121.3	4.41	4.38 to 4.44

[a] Only includes fish tracked toward the home stream.
[b] Period form time of fish release to time of movement past diffuser.
[c] Only includes depths during period of straight horizontal movement toward the home stream.
[d] Confidence interval.

All fish, except one, during treatment 3 headed toward the home stream and were exposed to the hydrocarbon plume. The mean duration of exposure to concentrations ranging 1 to 5 ppb and >5 ppb was 15.6 and 4.8 minutes, respectively (Table 3-7). Several fish were exposed to hydrocarbon concentrations greater than 10 ppb and ranging up to 18.1 ppb (Appendix D).

The horizontal movements of fish after exposure to the plume were different from fish movements observed during the control experiments. During treatment 3, most of the fish headed west across the bay in front of the plume similar to treatments 1 and 2 (e.g., Figures 3-29 and 3-30 at 17:30). Near the center of the bay the fish turn 180° and head back across the bay (Figures 3-29 and 3-30 at 18:00). This initial movement pattern was very similar to the patterns observed for fish during control 3. By the time the fish move back across the bay, the hydrocarbon plume had contaminated the eastern side and the fish move into the plume (Figures 3-29 and 3-30 at 18:30). While in the plume, fish exhibited a variety of horizontal movements.

Table 3-7: Duration of exposure to hydrocarbon concentrations greater than 1.0 ug/L (ppb) during treatment 3.

	Duration of Exposure (rein)	
Fish No.	1.0-5.0 (ppb)	>5.0 (ppb)
73	11.5	11.0
74	9.0	10.0
75	14.0	2.0
76	14.0	0.0
77	15.0	0.0
78	9.0	1.0
79	19,0	1.0
80	- -[a]	- -
81	4.0	2.0
82	41.5	3.0
83	13.0	4.0
84	13.0	0.0
85	12.0	0.0
86	21.0	15.0
87	7.0	6.0
88	23.0	6.0
89	18.5	5.0
90	20.0	15.0
91	- -[b]	- -
Mean	15.6	4.8
9590 C..[c]	11.2 to 19.9	2.1 to 7.4

[a] Fish left study area.
[b] Data deleted due to fish tracking problem.
[c] Confidence interval.

For example some fish swam slow, turned in the direction of the current, and headed downstream (e.g., Figure 3-30 at 18:30 and 19:00); some fish continued to *swim* relatively fast, moving in a circular pattern within the plume, and eventually heading downstream (e.g., Figure 3-29 at 18:30 and 19:00); and, one fish conducted several circular movements into and out of the plume before heading downstream (Figure 3-3 1). Most of the fish that headed downstream moved out of tracking range. After a period of 12 to 19 minutes these fish all returned toward the home stream, traveling a short distance along the outer edge of the plume through hydrocarbon concentrations near 1.0 ppb and the remaining distance outside the plume. During this latter portion of the return, the fish moved along a straight horizontal route similar to fish observed during control 3.

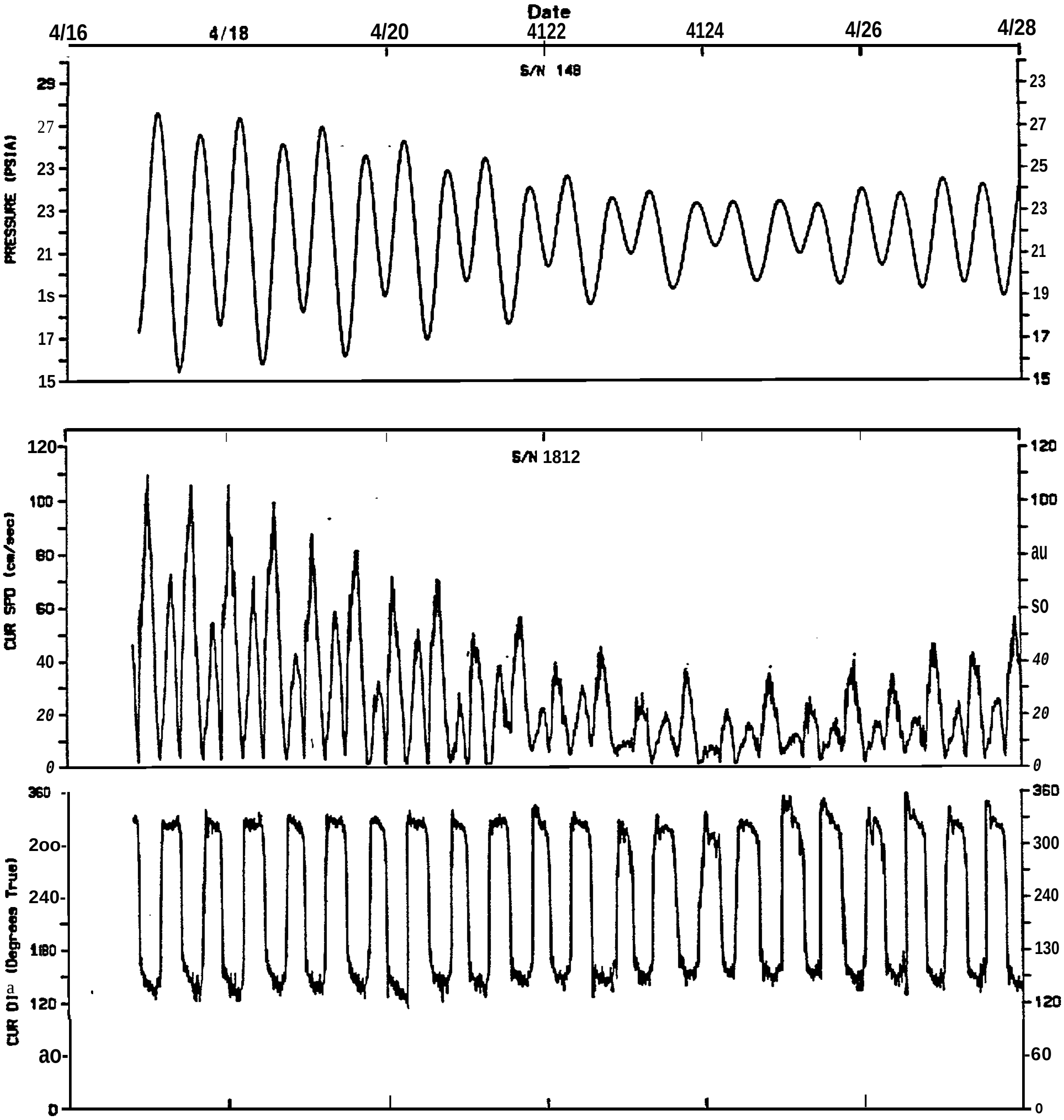
Fish nos. 77 and 82 exhibited a horizontal movement pattern quite different than the others (Figures 3-32 and 3-33). Instead of moving across the bay ahead of the plume, these fish slowly moved to the center of the bay and stopped at approximately 18:00 hours. Between 18:00 and 18:30 both fish became entrained in the hydrocarbon plume. Fish nos. 77 and 82 were exposed to concentrations greater than 1.0 ppb for 15 and 30 minutes, respectively. During this period both fish turned downstream and eventually headed out of the plume (Figures 3-32 at 18:30 and 3-33 at 18:30-1900). However, the distance each fish moved down bay was different. Fish no. 77 only moved a short distance before turning 180° and headed toward the home stream (Figure 3-32 at 19:00), whereas fish no. 82 continued downstream and headed back into the plume before going out of tracking range (Figure 3-33 at 1900). During the return toward the home stream fish no. 82 swam through hydrocarbon concentrations >1.0 ppb for at least 200 m before heading outside of the plume. Several other fish also had a short (i.e., <2 minutes) exposure to the plume during the return migration.

The amplitude of vertical movements did not appear to be affected by exposure to the hydrocarbon plume. The pattern of large- and small-amplitude vertical movements that occur prior to exposure generally continue during exposure. Many fish had small-amplitude movements throughout the return period (e.g., Figure 3-34). In many cases the pattern of these movements during the period of swimming downstream was similar to the pattern during the period of straight horizontal movement upstream. Some fish had a mixture of large- and small-amplitude vertical movements (e.g., Figure 3-35, fish no. 73), and some had a high frequency of large-amplitude vertical movements (e.g., Figure 3-35, fish no. 83). During active movement toward the home stream, all fish displayed small-amplitude vertical movements similar to those observed during control experiments.

The swimming speed of fish varied significantly during the return period (Figures 3-34 and 3-35). After the initial escape from the holding pen but prior to exposure to the hydrocarbon plume, fish swam very slow (mean ground speed of 0.08 m/s). However, during exposure to the plume swimming speeds increased significantly ($P < 0.001$) to an average ground speed of 0.31 m/s (Appendix G). Swimming speeds were highest (mean ground speed of 0.82 m/s) following exposure to the plume and during the period of straight horizontal movement toward the home stream. This increase in swimming speed from the period of searching to the period of active migration was similar to the pattern observed during the control experiments.

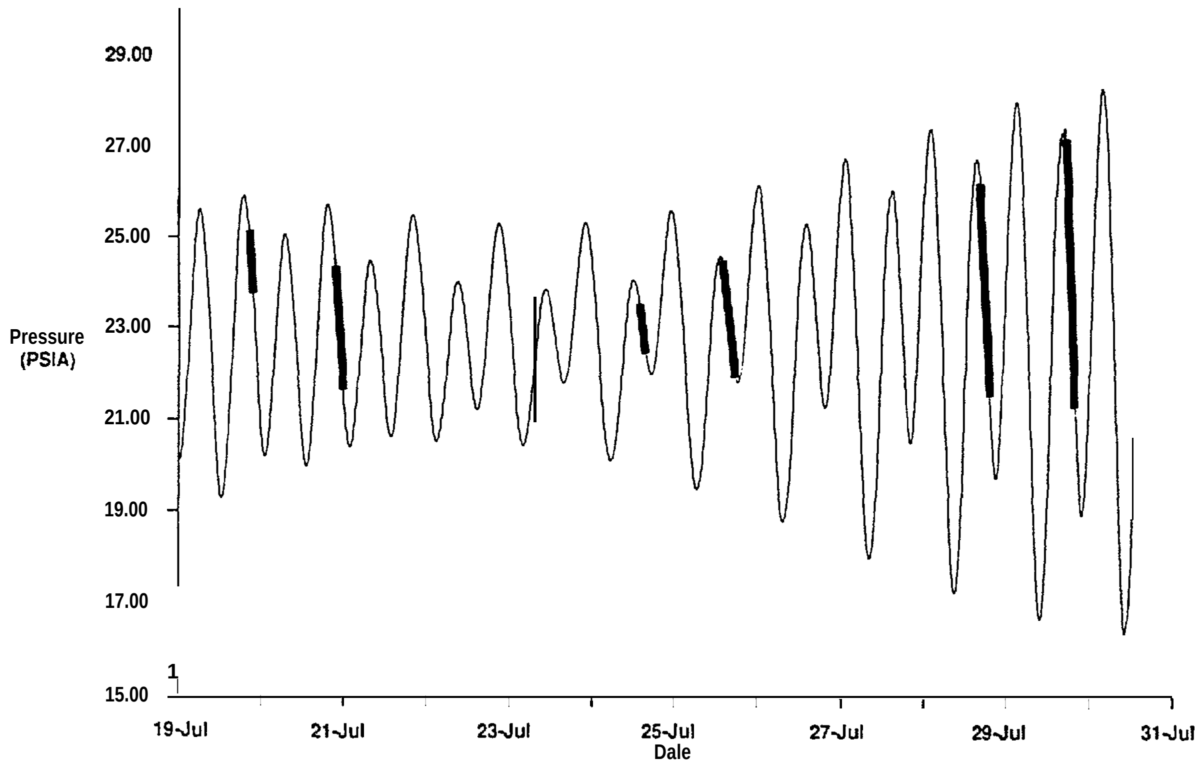
The average depth of treatment 3 fish during the period of straight horizontal movement toward the home stream was significantly ($p<0.05$) greater than all other experiments (Appendix G) and was not associated with the interface of the vertical salinity gradient. All fish heading toward the home stream swam at an average depth of 4.4 m (Table 3-6), which was approximately 3 m deeper than the interface between the low salinity surface waters and the higher salinity bottom waters (Figure 3-36). Water depth was just over 6 m as indicated by the depth of the salinity profiles, therefore the fish were swimming less than 2 m above the bottom.

The duration-of-return period during treatment 3 averaged 1 I 8.5 minutes (Table 3-6) and was significantly ($P<0,001$) longer than all the control experiments (Table 3-6 and Appendix G). The longer duration-of-return was due to the longer duration of searching by fish prior to active movement toward the home stream.

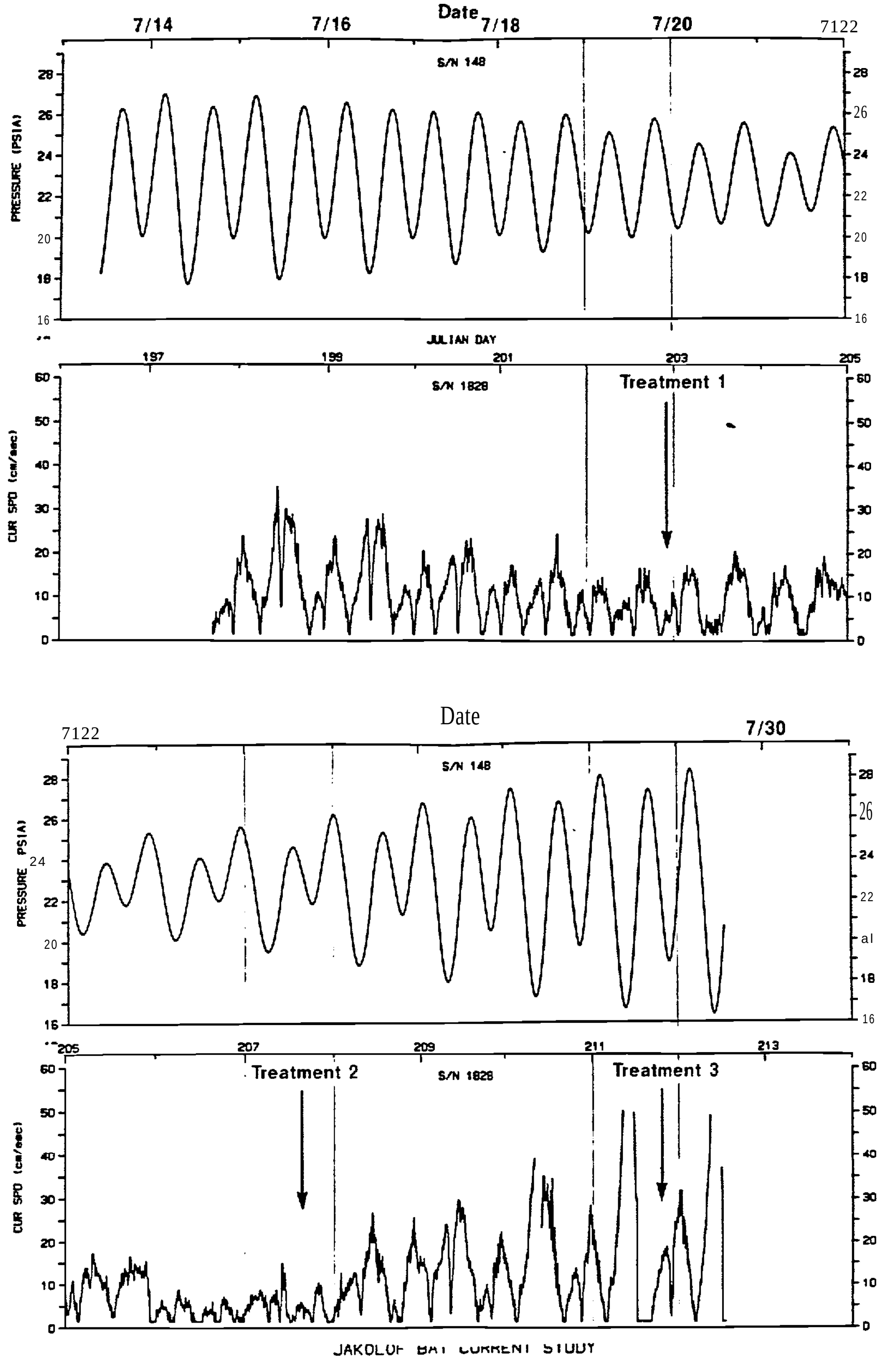


JAKOLOF BAY CURRENT STUDY

Tides and Currents At Mouth of Jakolof Bay During Reconnaissance Survey
Figure 3-1

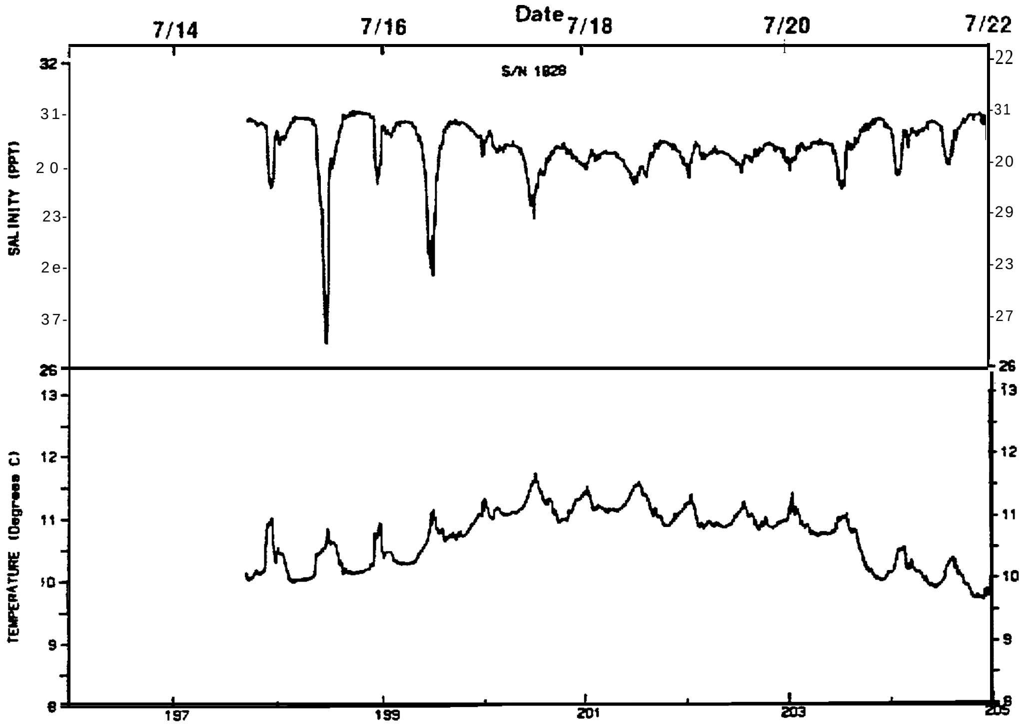


Tides At Station 2 During Fish Tracking Experiments
(PISA = 1lbs/in² in Addition to Atmospheric Pressure)
Figure 3-2

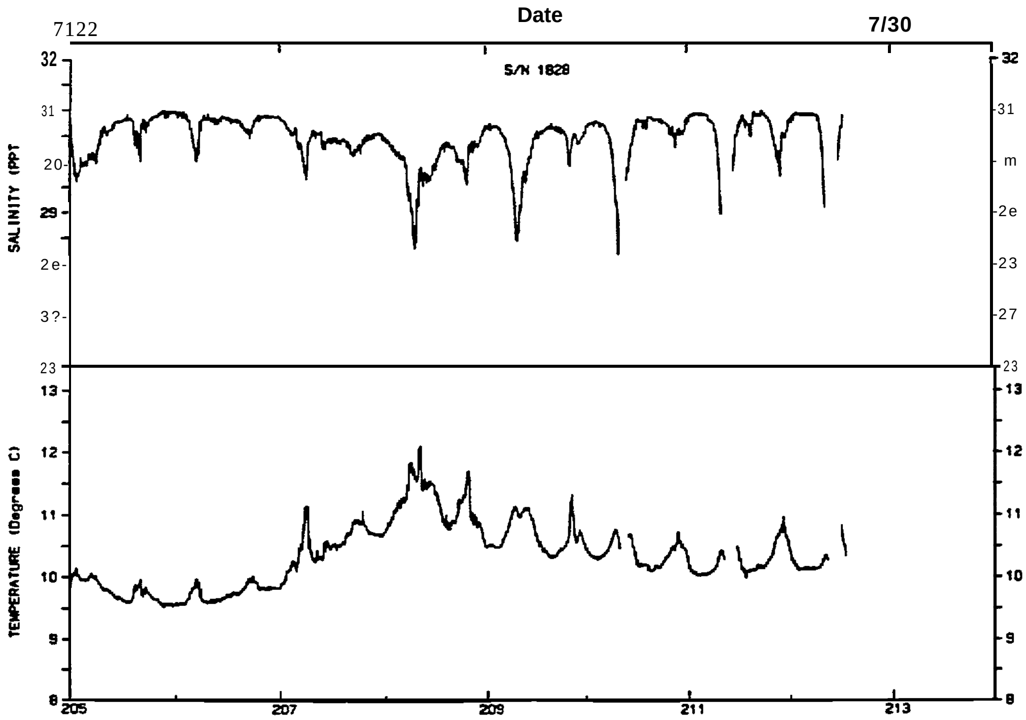


Currents at Diffuser During Experiments

Figure 3-3

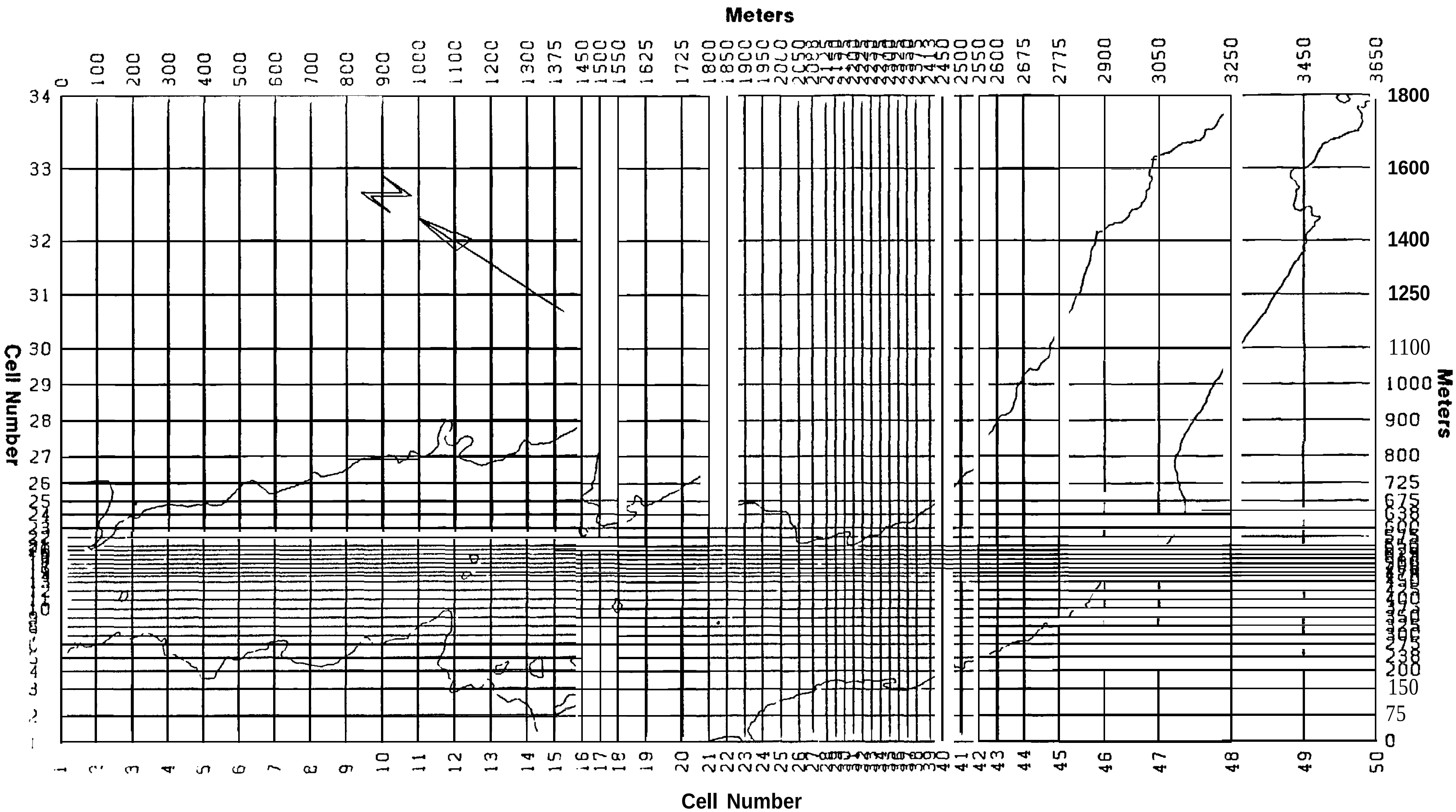


JAKOLOF BAY CURRENT STUDY



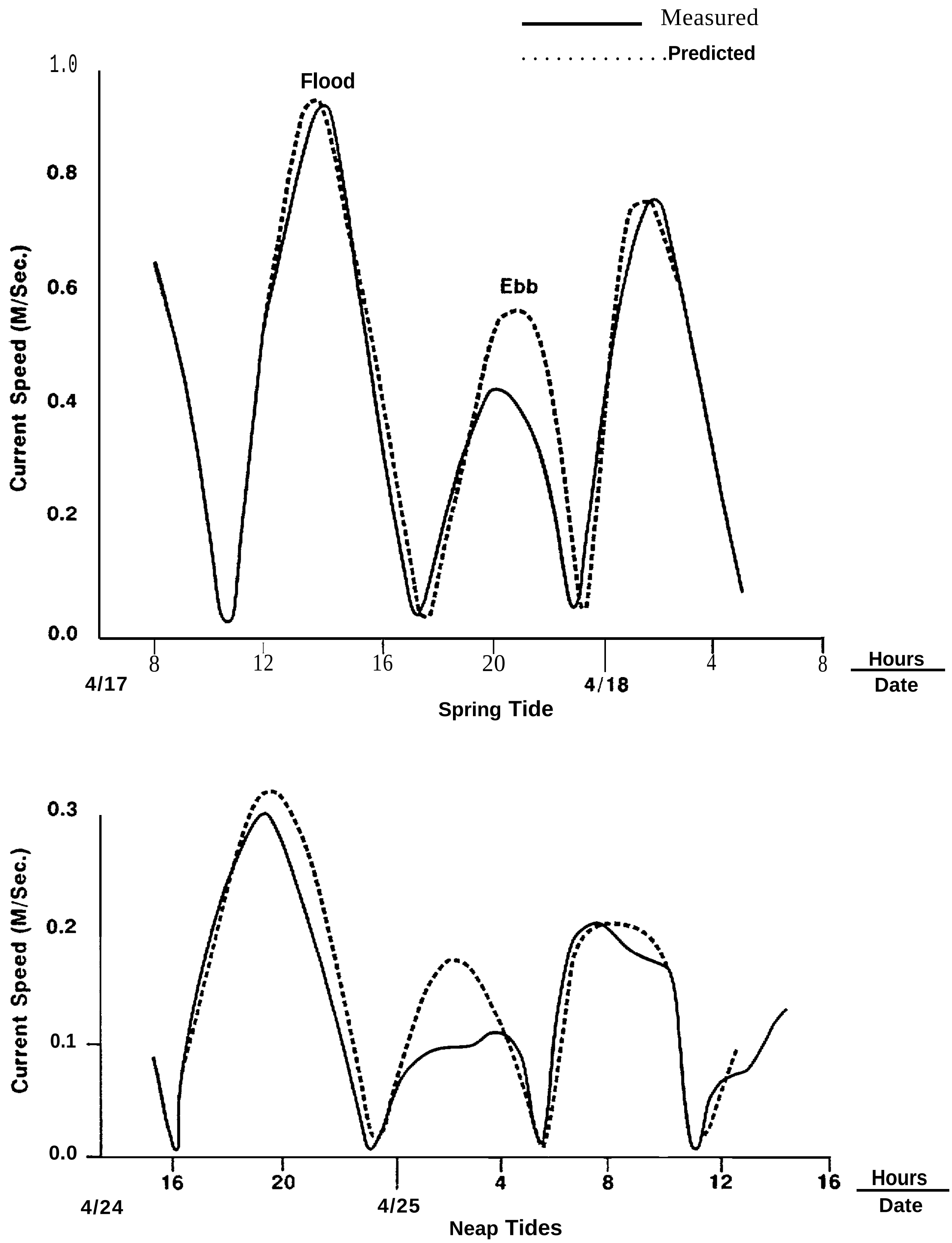
JAKOLOF BAY CURRENT STUDY

Temperature and Salinity at Diffuser During Experiments
Figure 3-4



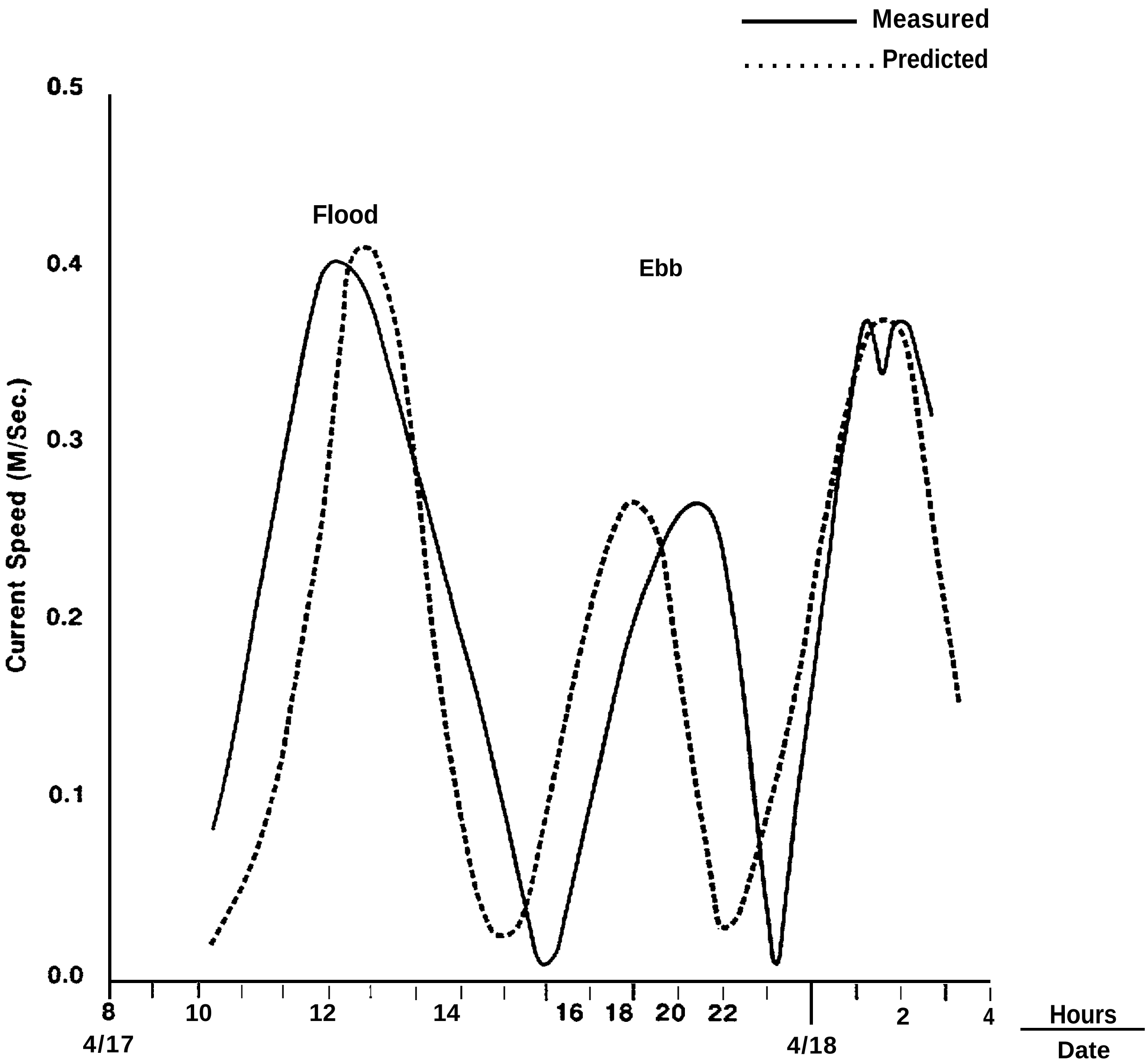
Finite - Difference Grid

Figure 3-5



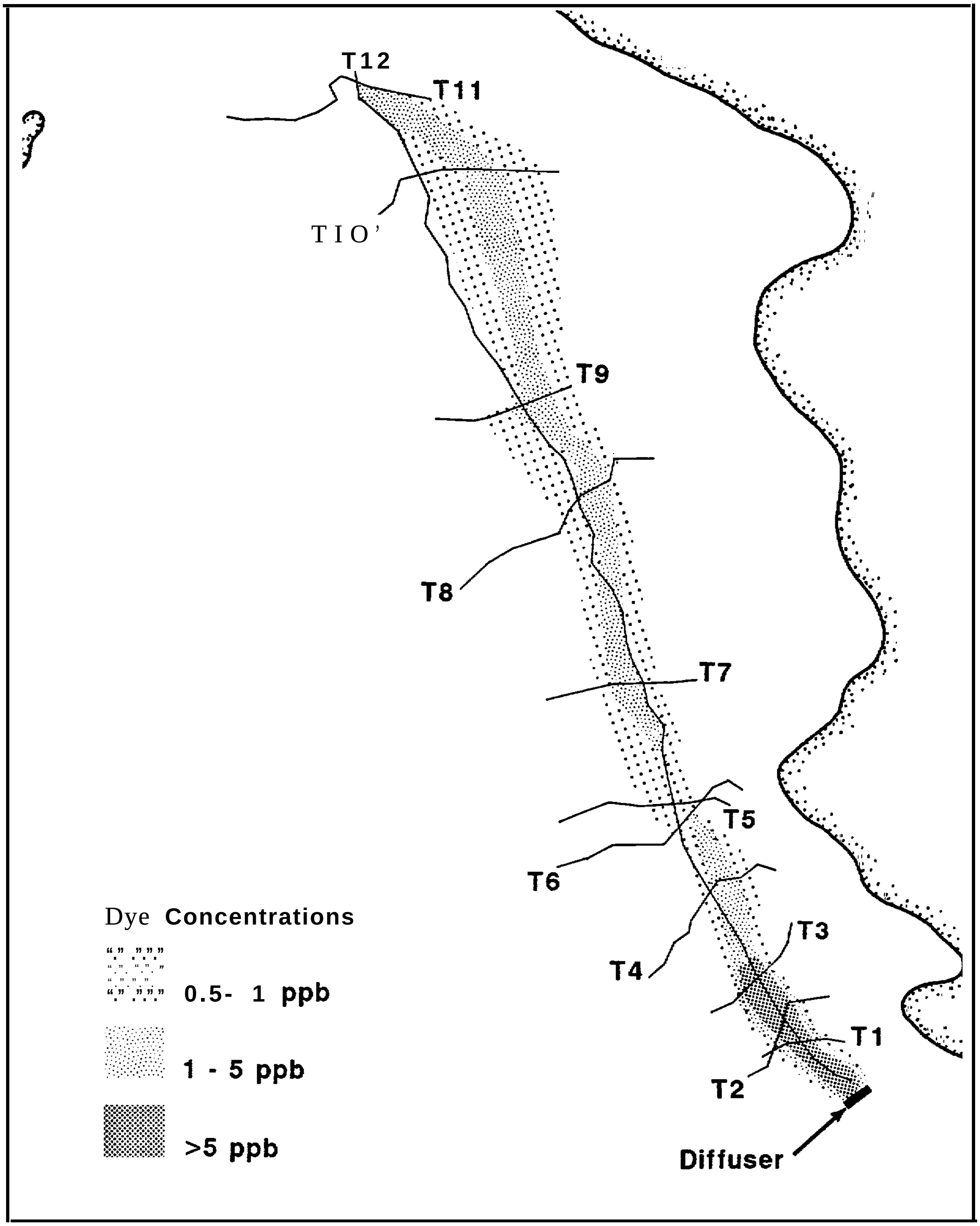
Hydrodynamic Calibration, Currents at Mouth of Jakolof Bay (Sta. 1)

Figure 3-6



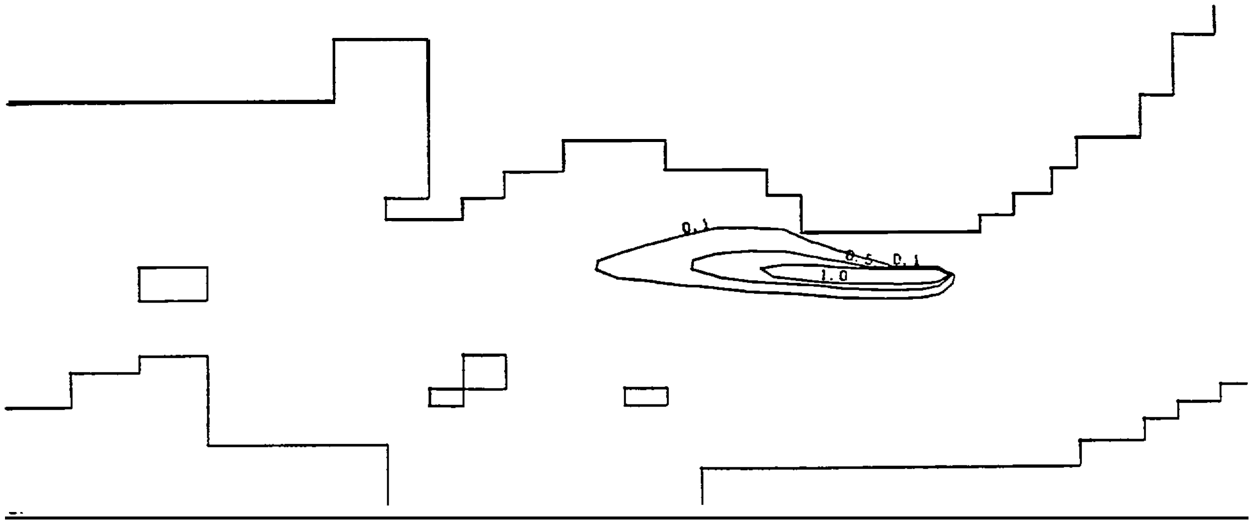
Hydrodynamic Calibration, Currents Near Center of Jakolof Bay (Sta. 2)

Figure 3-7

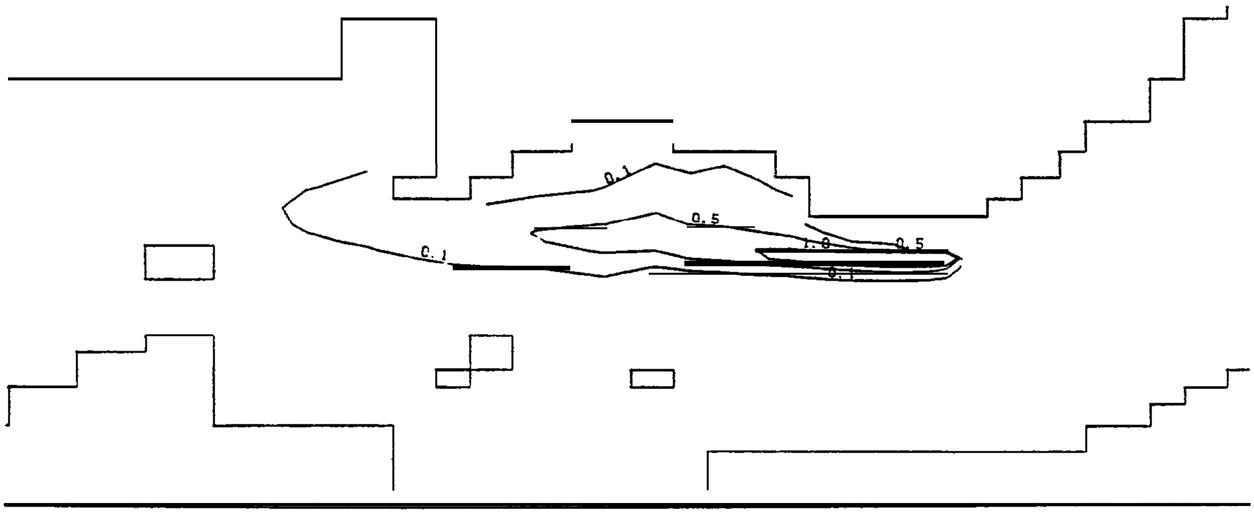


Dye Concentrations (ppb) Used for Water Quality Calibrations

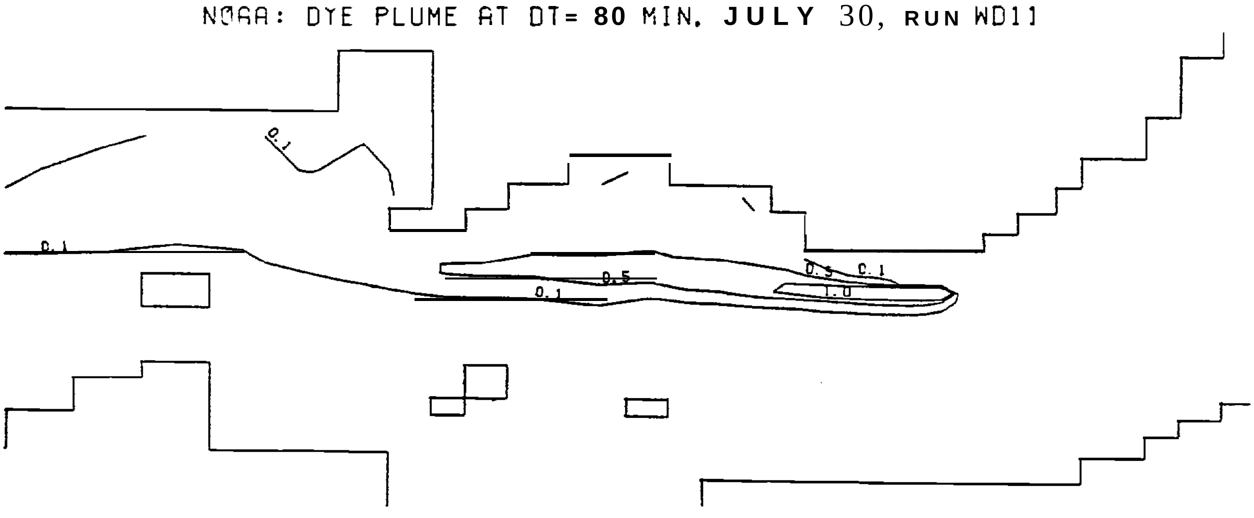
Figure 3-8



NOAA: DYE PLUME AT DT= 40 MIN. JULY 30. RUN WD11

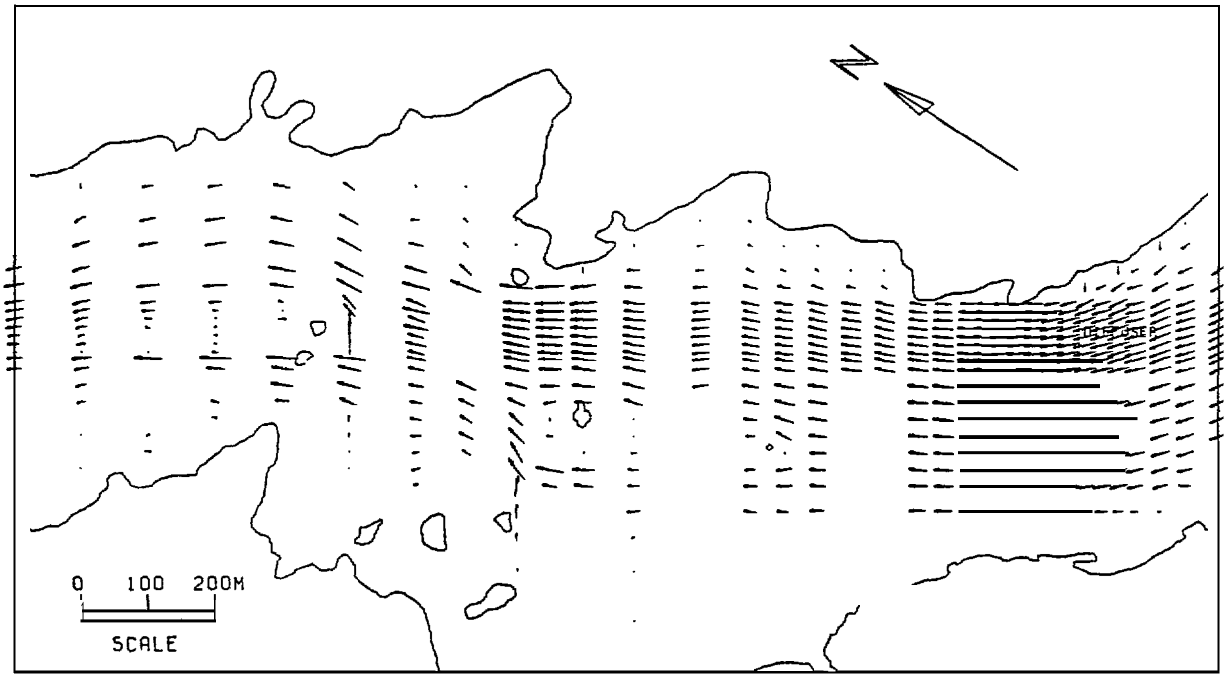


NOAA: DYE PLUME AT DT= 80 MIN. JULY 30, RUN WD11



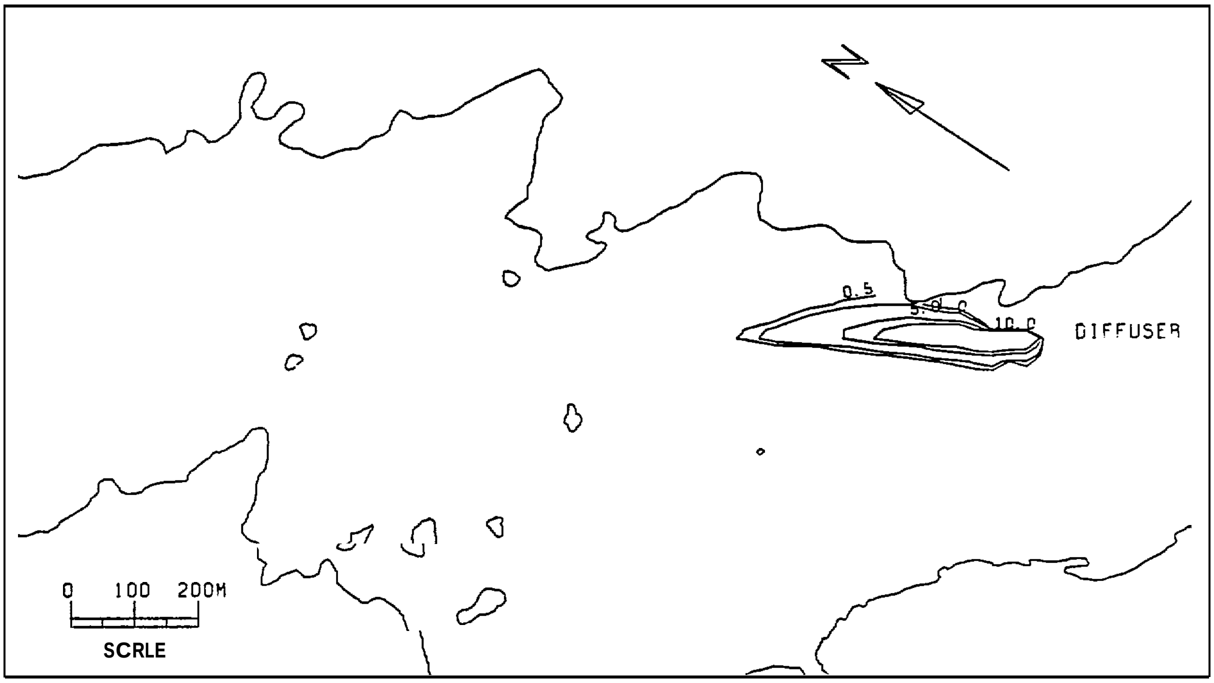
NOAA: DYE PLUME ATDT= 120 MIN. JULY 30. RUN WD11

Water Quality Calibration, Predicted Concentrations (ppb)
Figure 3-9

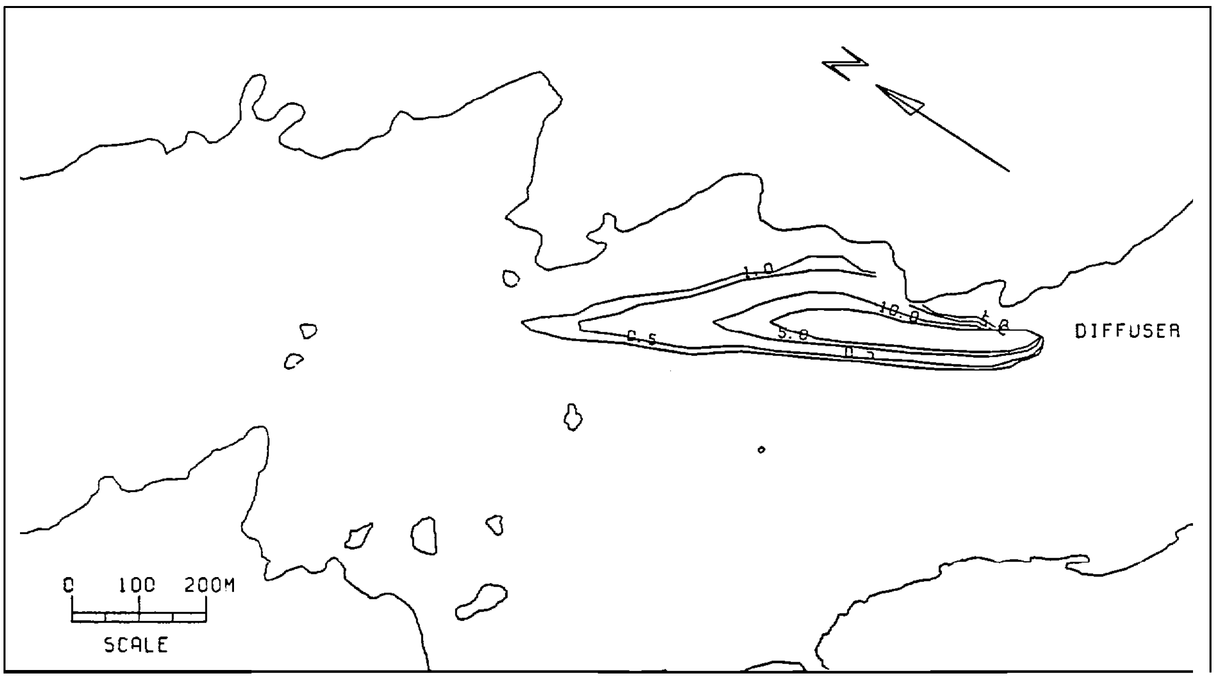


1.00 E+00 VEC. UNITS/PLOT INCH
TREATMENT NO. 1, 7/20/89, VECTORS AT 24:00 (+2.5 HR)

Vector Plot of Currents on 7/20/88
Figure 3-10

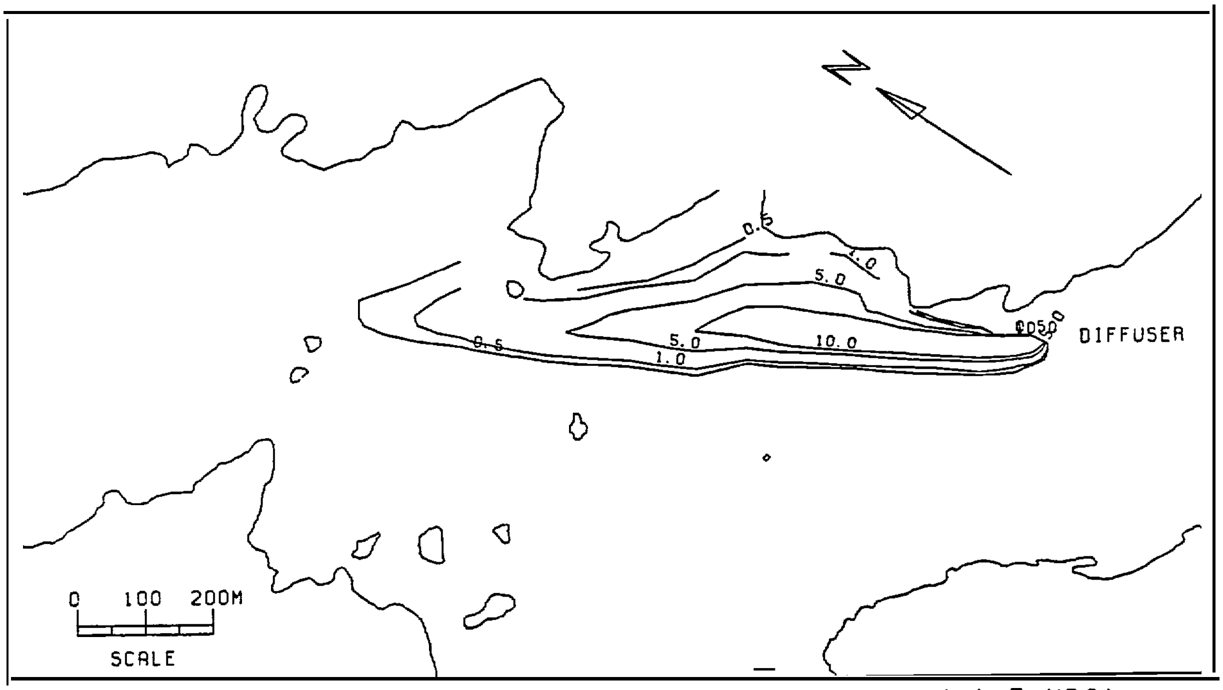


TREATMENT NO. 1, 7/20/89, PLUME AT 22:00 (+0.5 HRS)

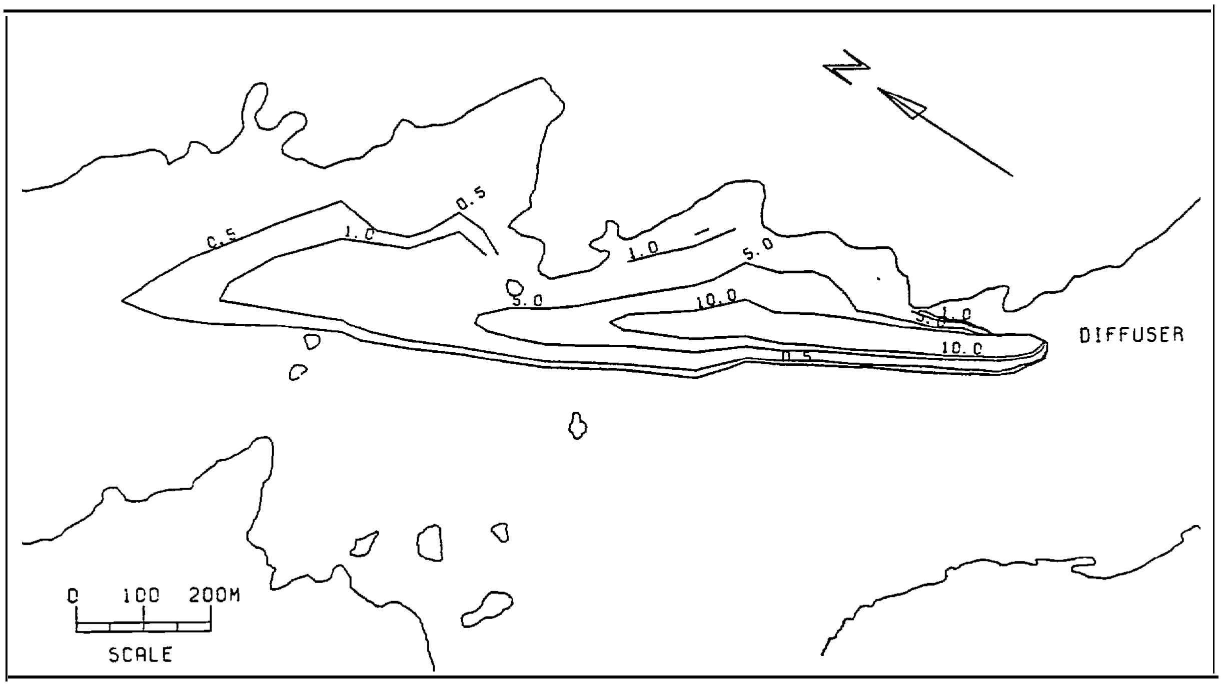


TREATMENT NO. 1, 7/20/89, PLUME AT 22:30 (+1.0 HRS)

Predicted Hydrocarbon Concentrations (ppb) During Treatment 1
Figure 3-11



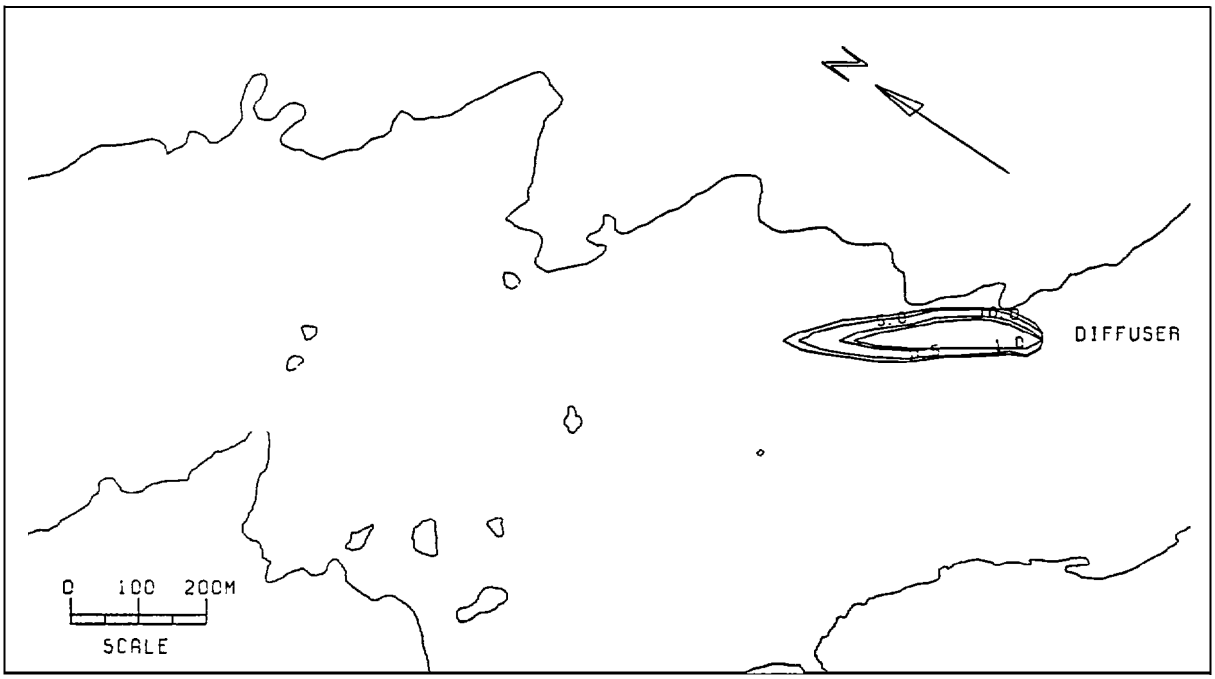
TREATMENT NO. 1, 7/20/89, PLUME AT 23:00 (+1.5 HRS)



TREATMENT NO. 1, 7/20/89. PLUME AT 23:30 (+2.0 HRS)

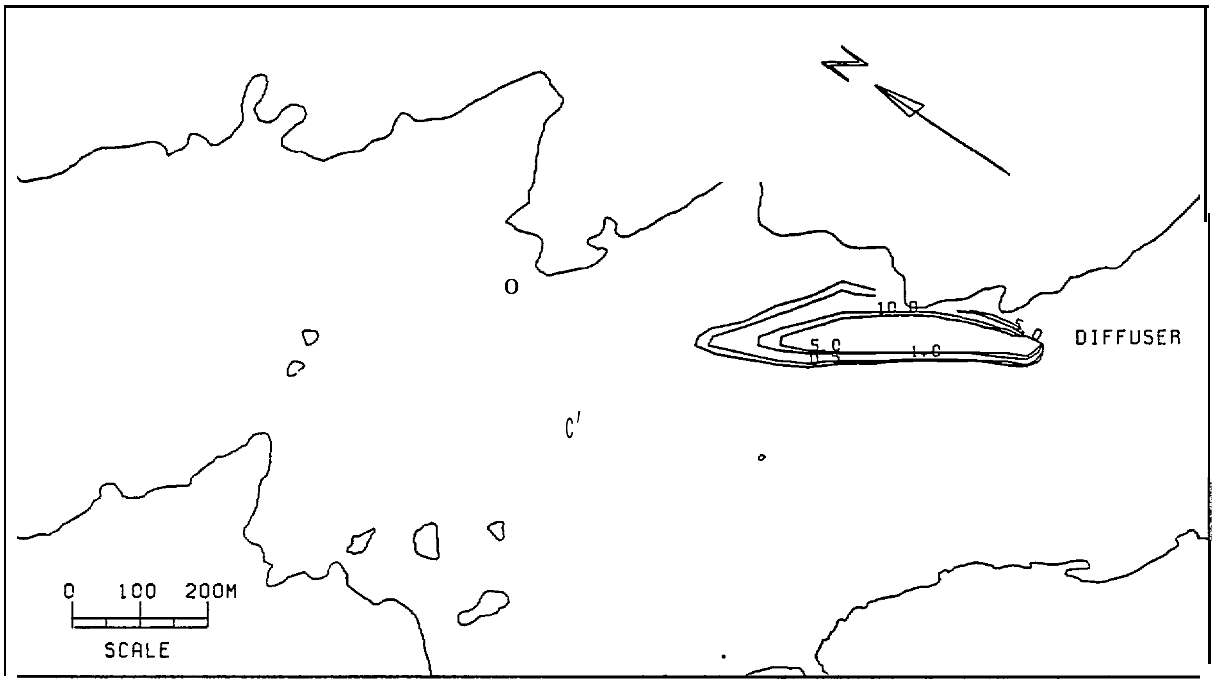
Predicted Hydrocarbon Concentrations (ppb) During Treatment 1
Figure 3-11 (continued)

TREATMENT NO. 2, 7/25/89, PLUME AT14:00 (+0.5 HRS)

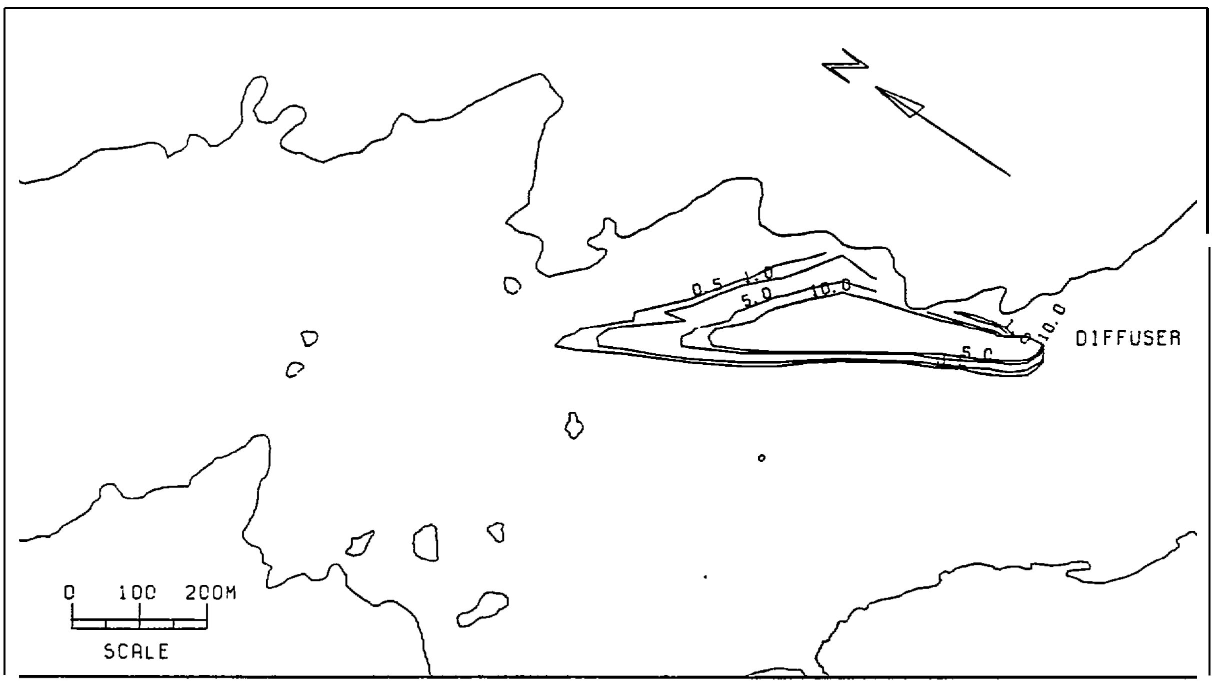


TREATMENT NO. 2, 7/25/89. PLUME AT14:30 (+1.0 HRS)

Predicted Hydrocarbon Concentrations (ppb) During Treatment 2
Figure 3-12

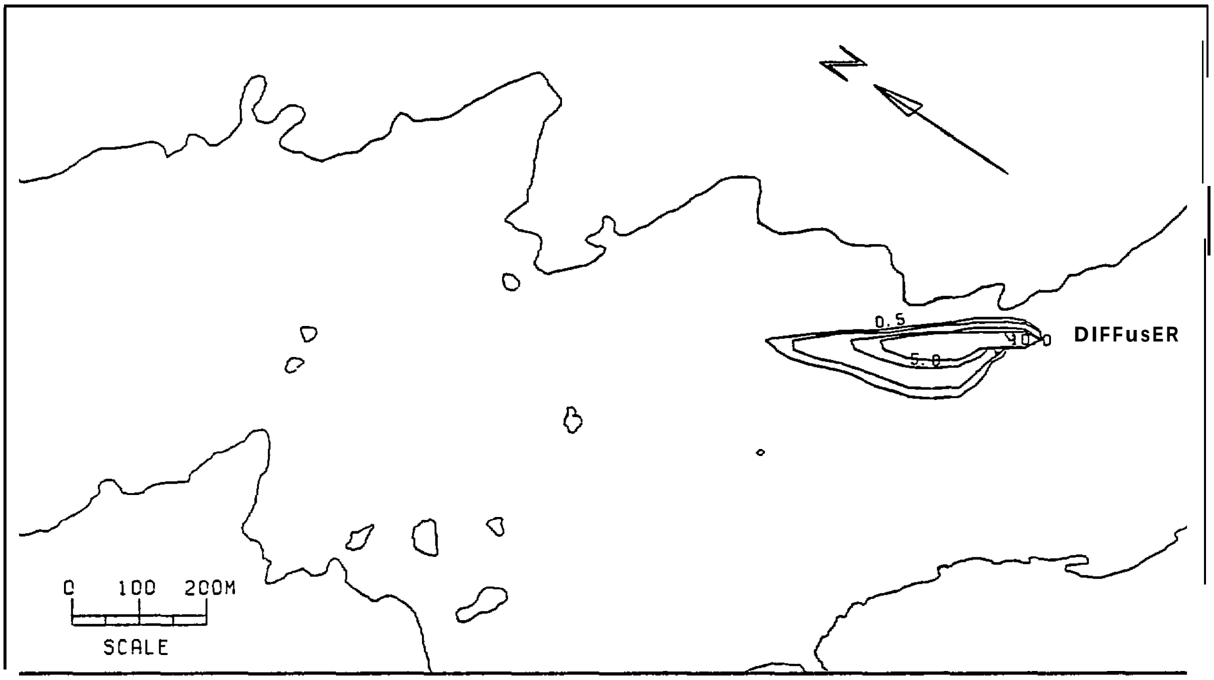


TREATMENT NO. 2, 7/25/89, PLUME AT 15:00 (+1.5 HRS)

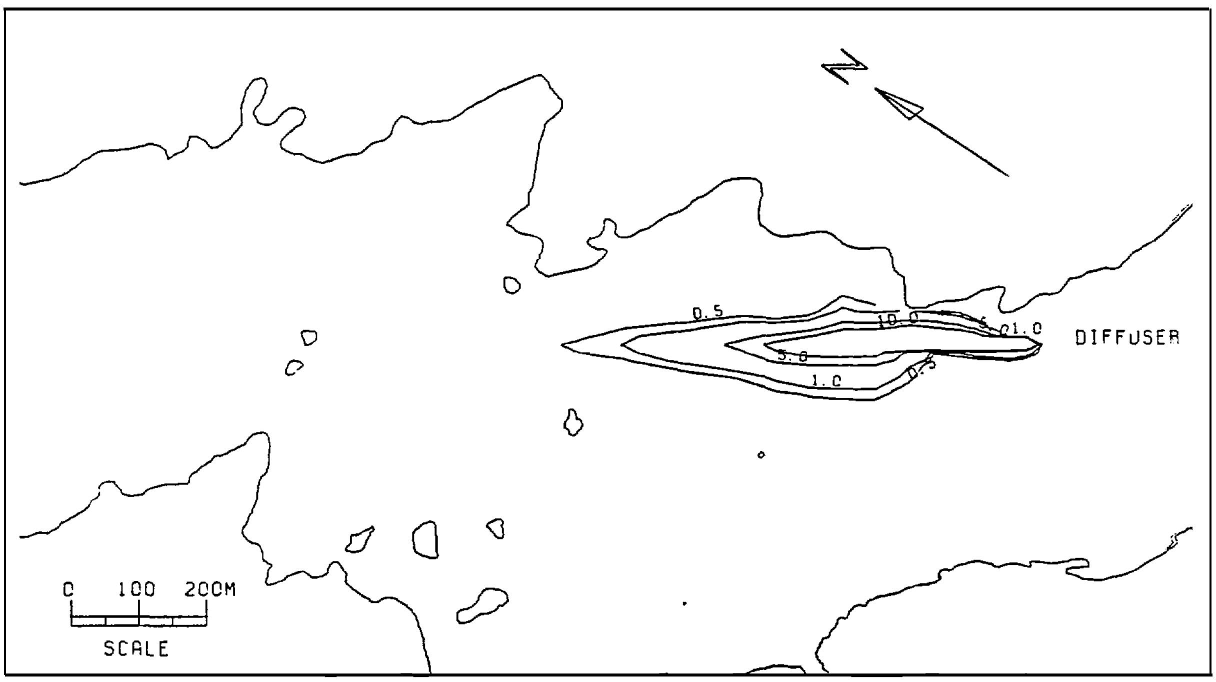


TREATMENT NO. 2, 7/25/89. PLUME AT15:30 (+2.0 HRS)

Predicted Hydrocarbon Concentrations (ppb) During Treatment 2
Figure 3-12 (continued)

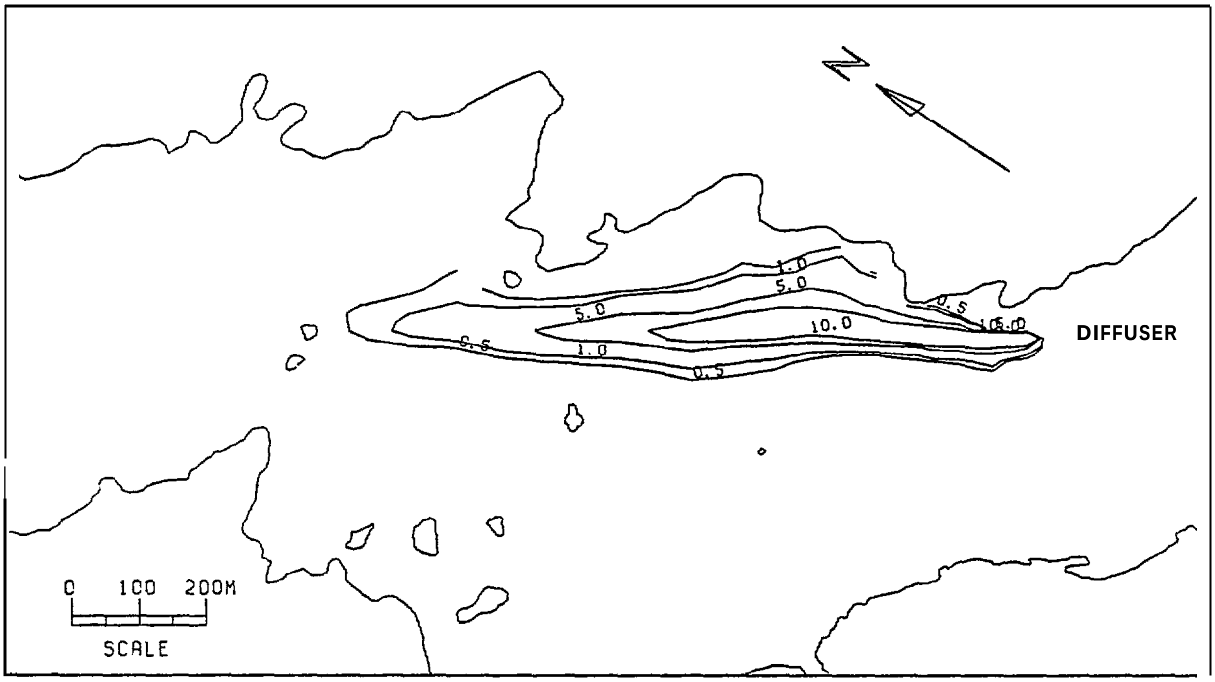


TREATMENT NO. 3, 7/29/89. PLUME AT 17:30 (+1.0 HRS)

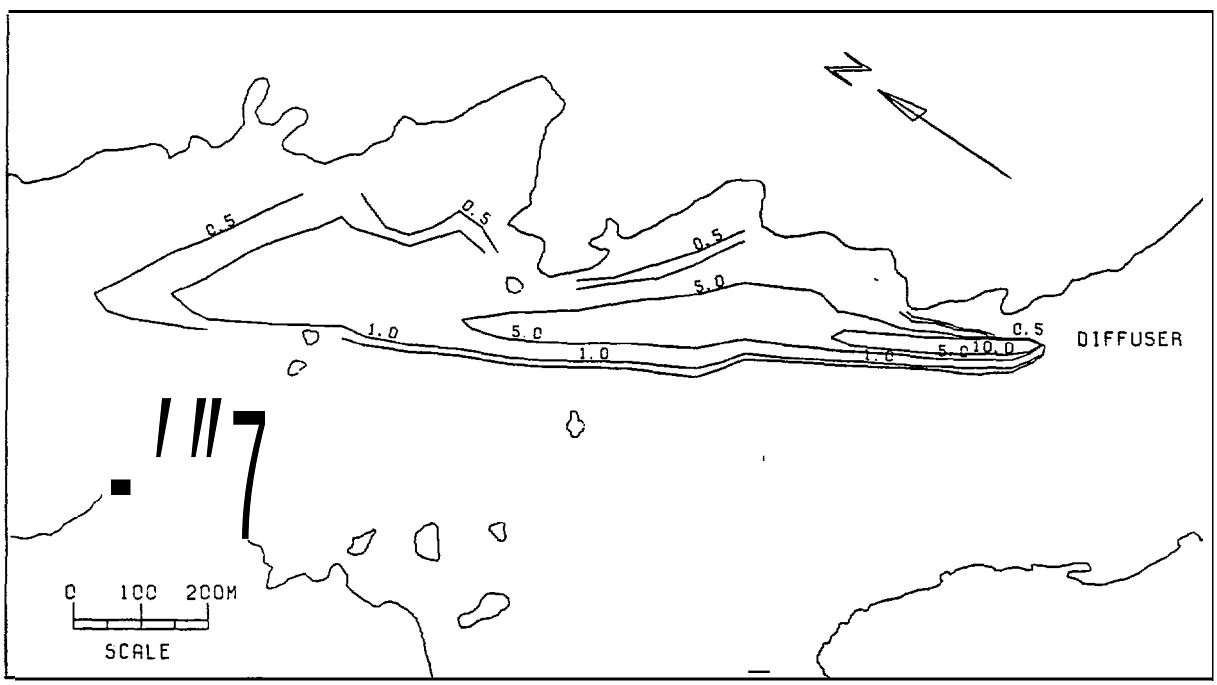


TREATMENT NO. 3, 7/29/89, PLUME AT 18:00 (+1.5 HRS)

Predicted Hydrocarbon Concentrations (ppb) During Treatment 3
Figure 3-13

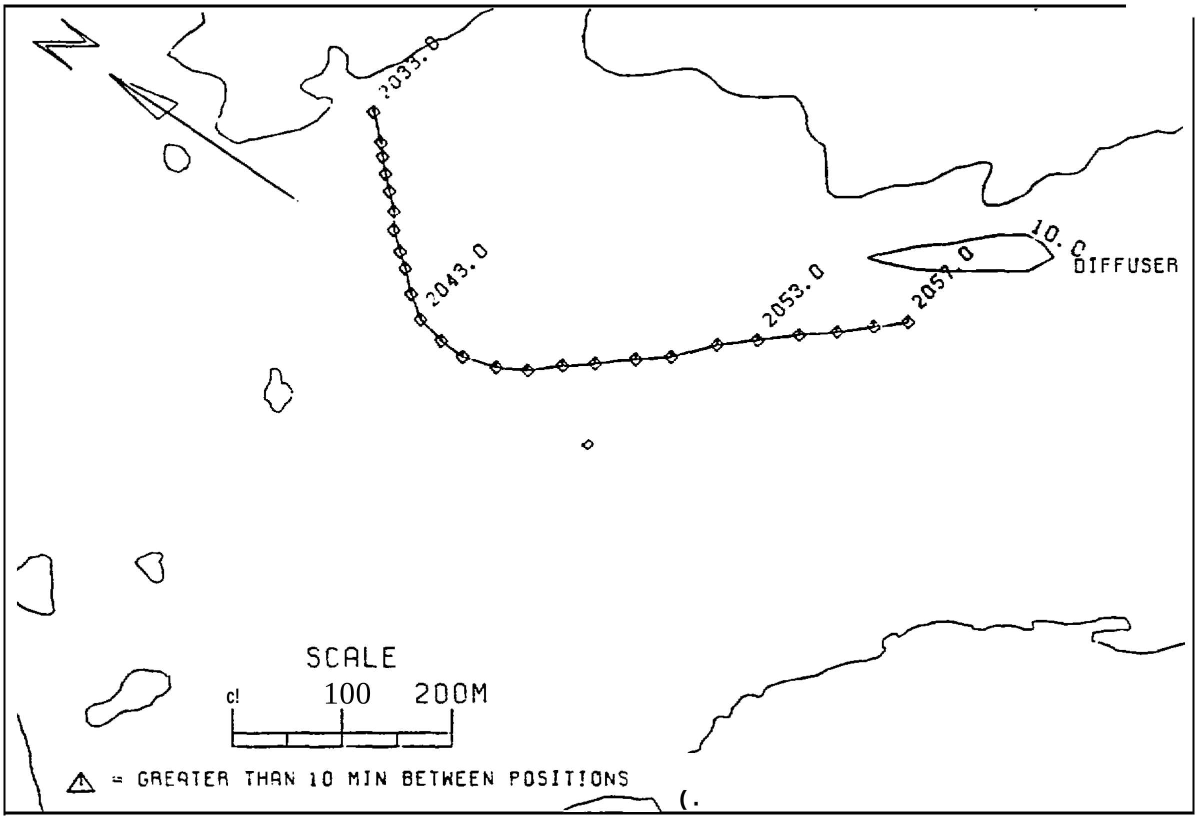


TREATMENT NO. 3, 7/29/89, PLUME AT18:30 (+2.0 HRS)

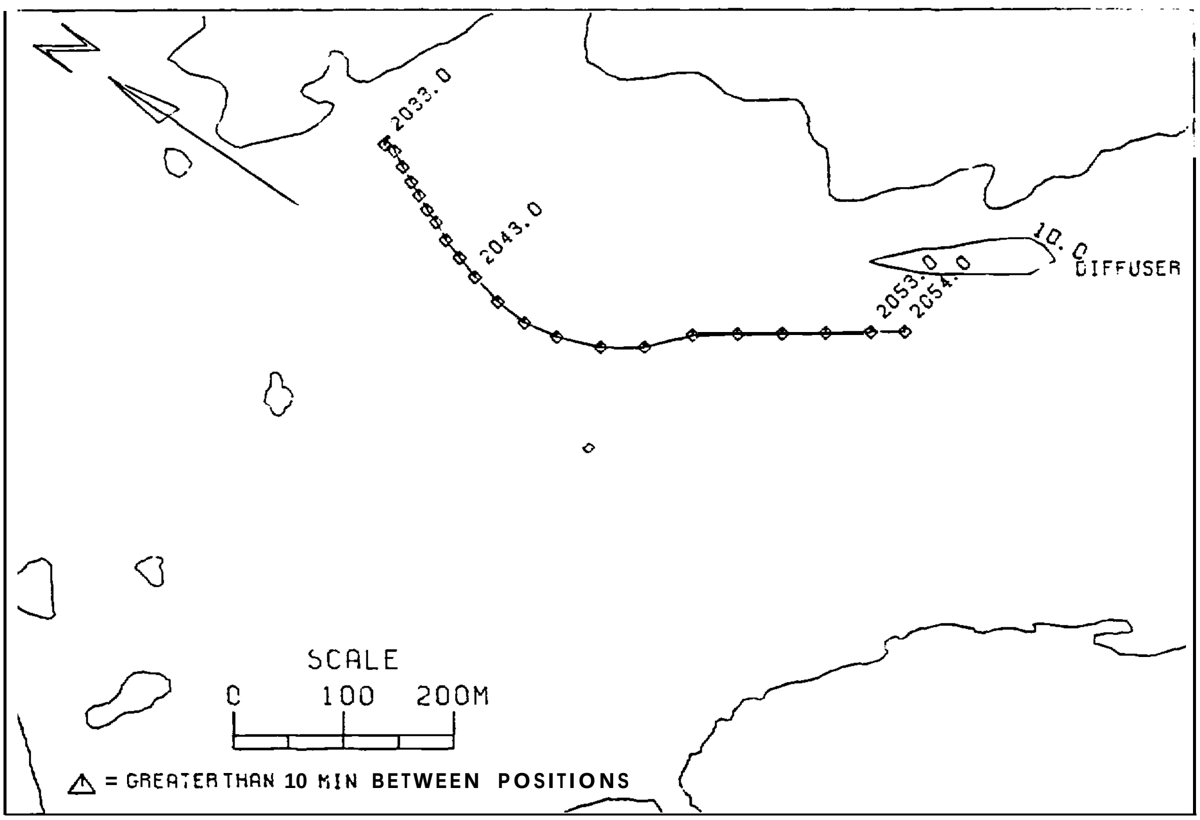


TREATMENT NO. 3, 7/29/89, PLUME AT19:00 (+2.5 HRSI

Predicted Hydrocarbon Concentrations (ppb) During Treatment 3
Figure 3-13 (continued)

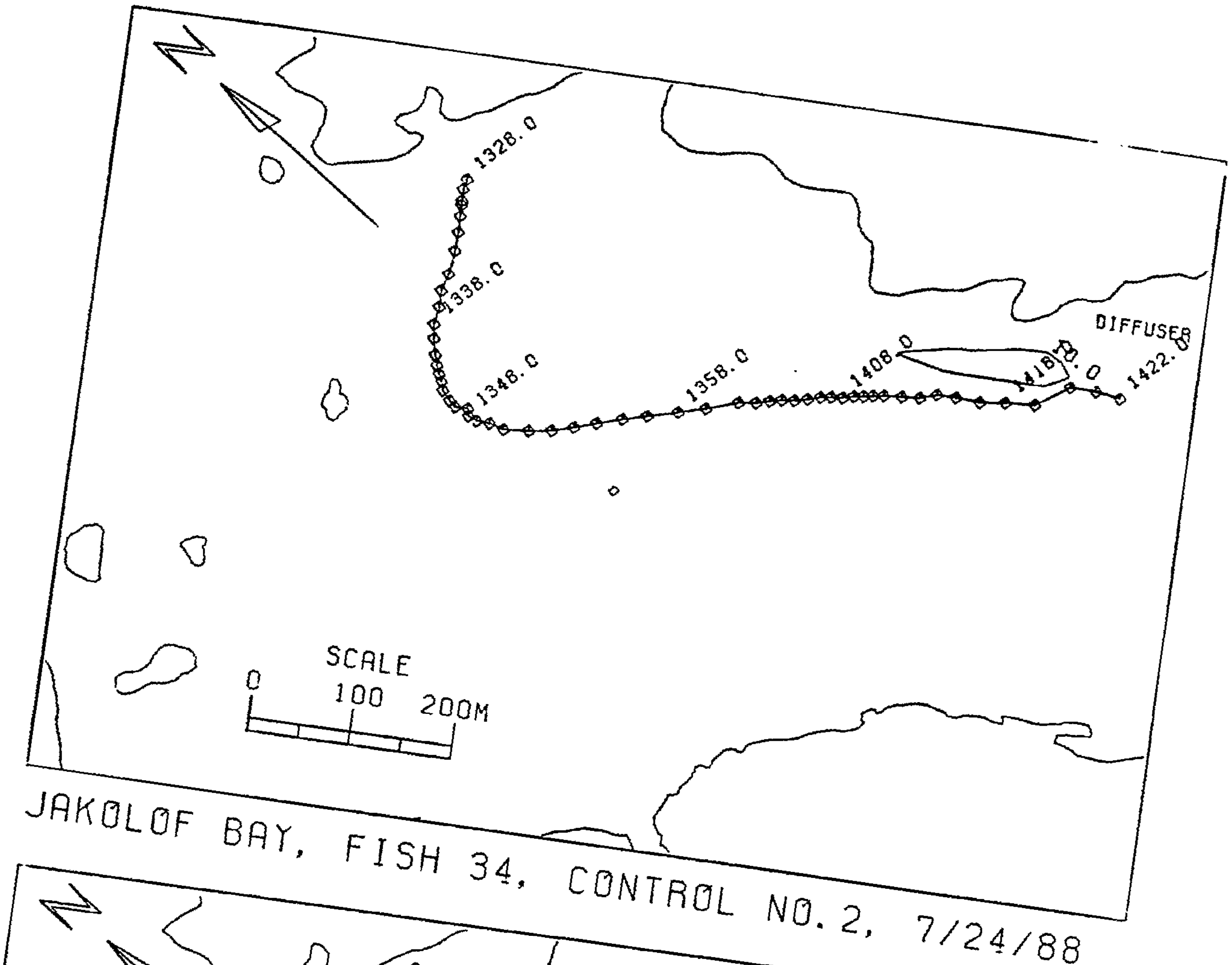


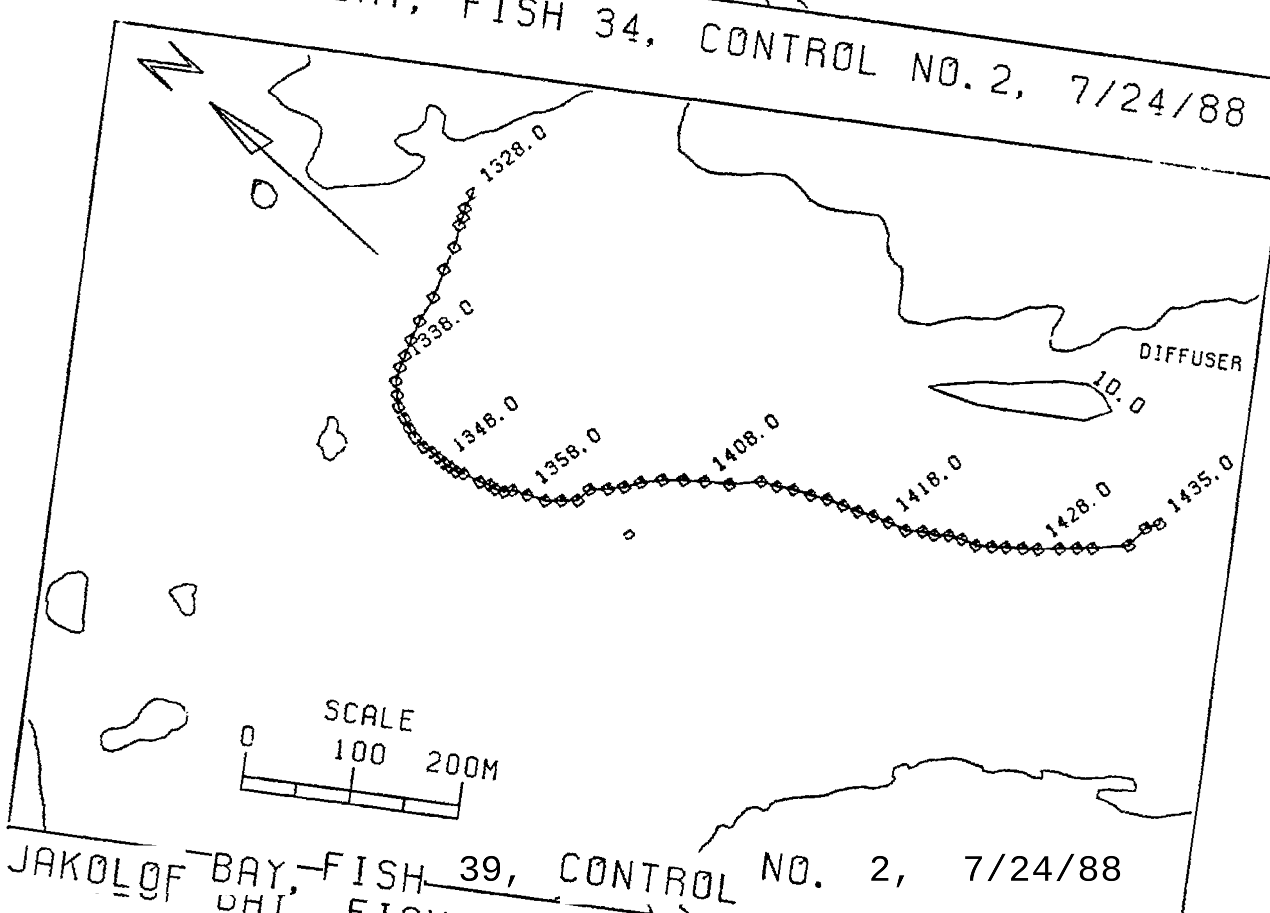
JA KOLOF BAY, FISH 09, CONTROL NO.1, 7/19/88



JA KOLOF BAY, FISH 10, CONTROL NO. 1, 7/19/'88

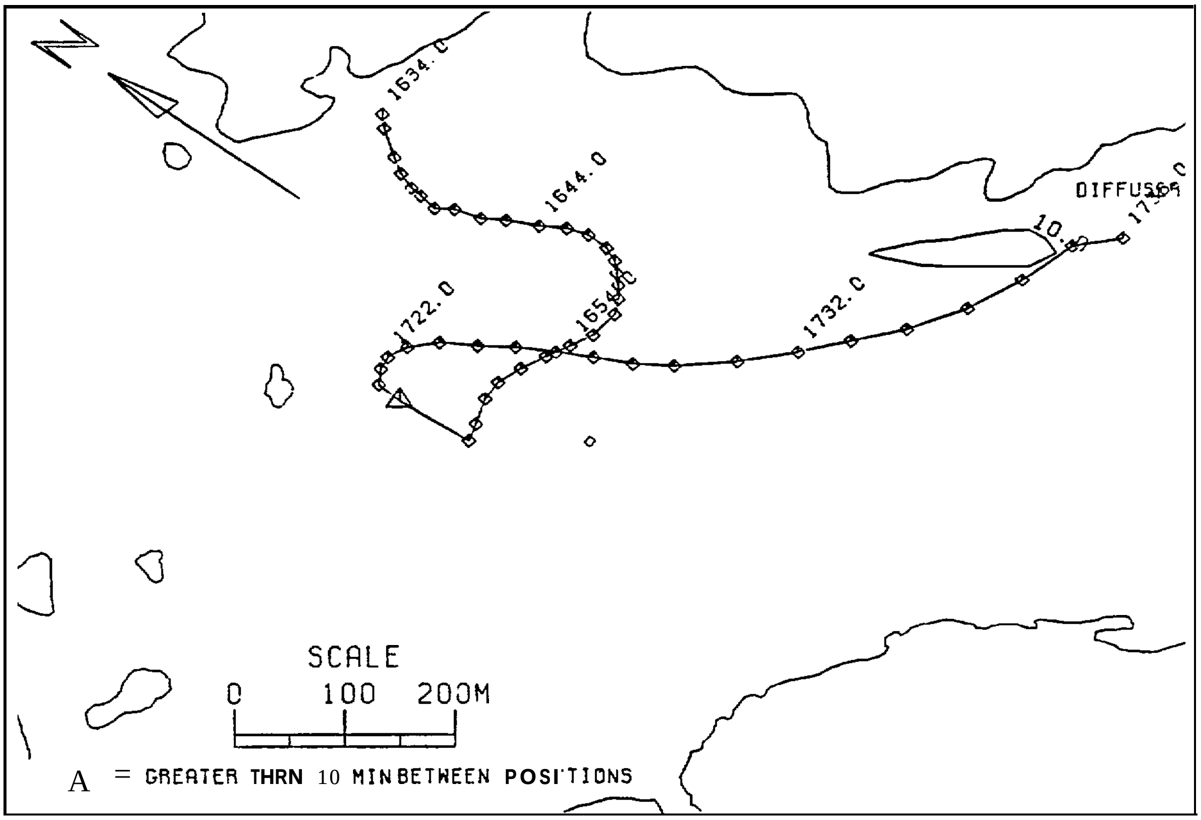
Horizontal Movements of Fish Numbers 9 and 10 During Control 1
Figure 3-14



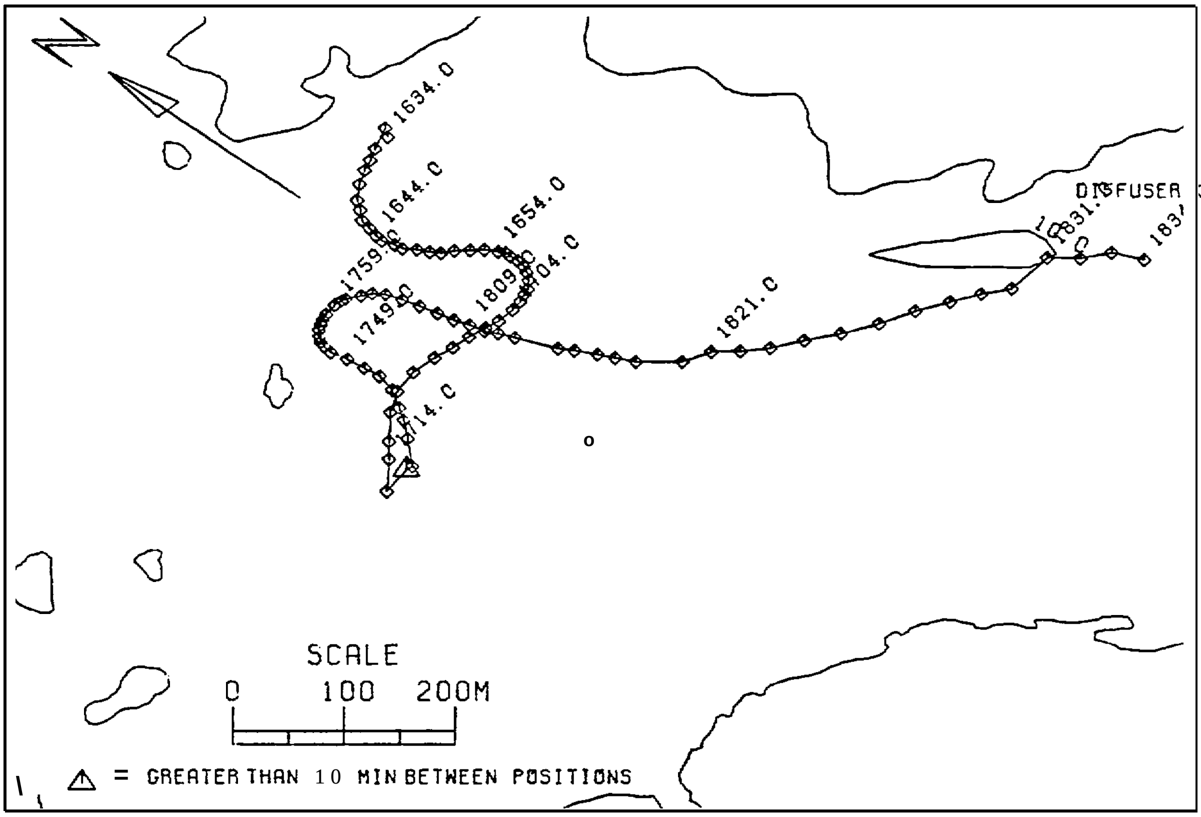


Horizontal Movements of Fish Numbers 34 and 39 During Control 2

Figure 3.15



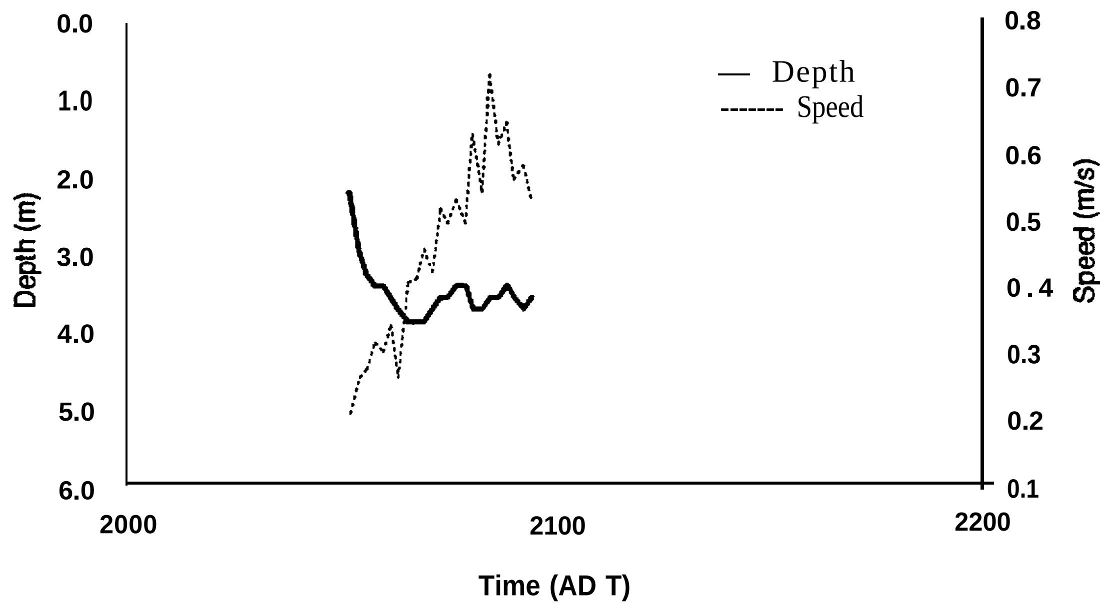
JAKOLOF BAY, FISH 58, CONTROL NO. 3, 7/28/88



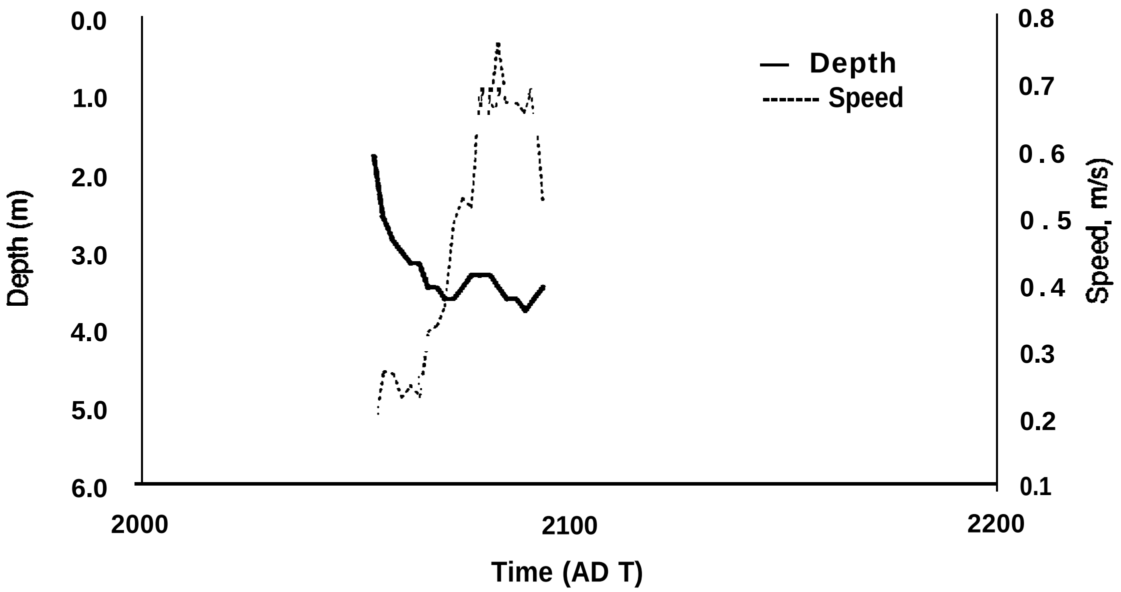
JAKOLOF BAY, FISH 72, CONTROL NO. 3, 7/28/88

Horizontal Movements of Fish Numbers 58 and 72 During Control 3
Figure 3-16

Control No. 1
Fish No. 9

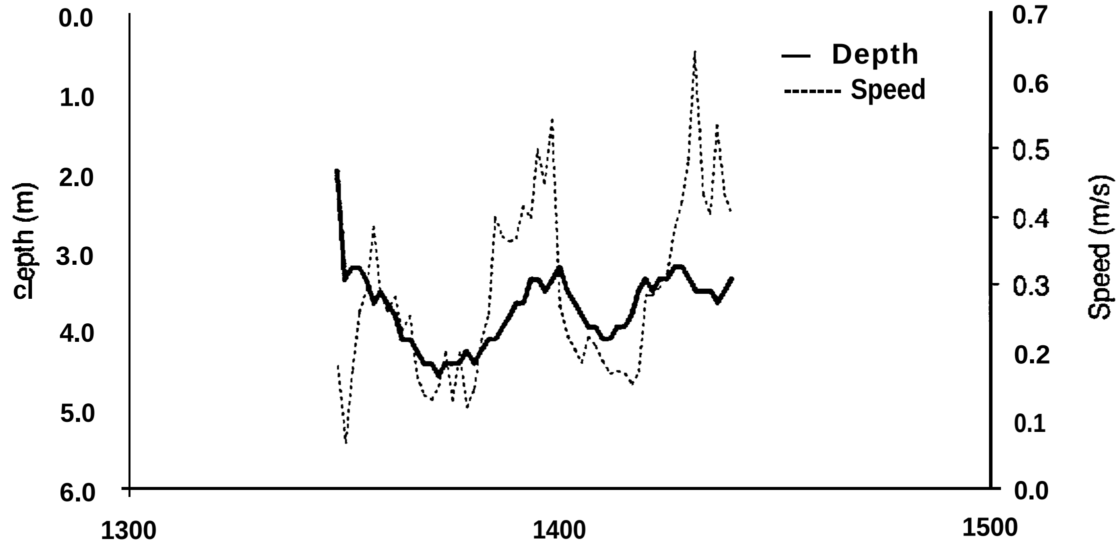


Control No. 1
Fish No. 10

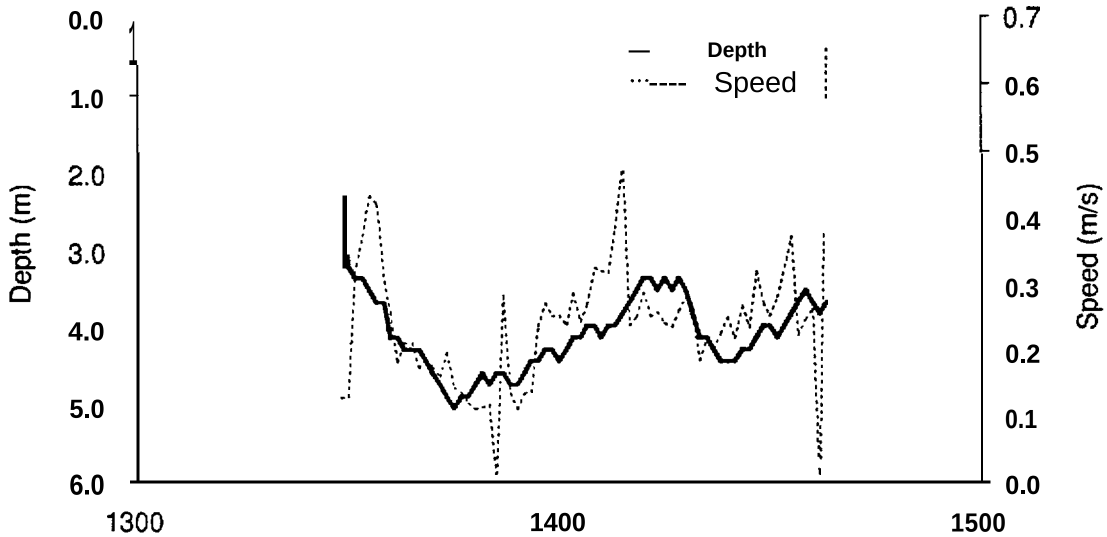


Depth and Ground Speed Versus Time for Fish Numbers 9 and 10 During Control 1
Figure 3-17

Control No. 2
Fish No. 34

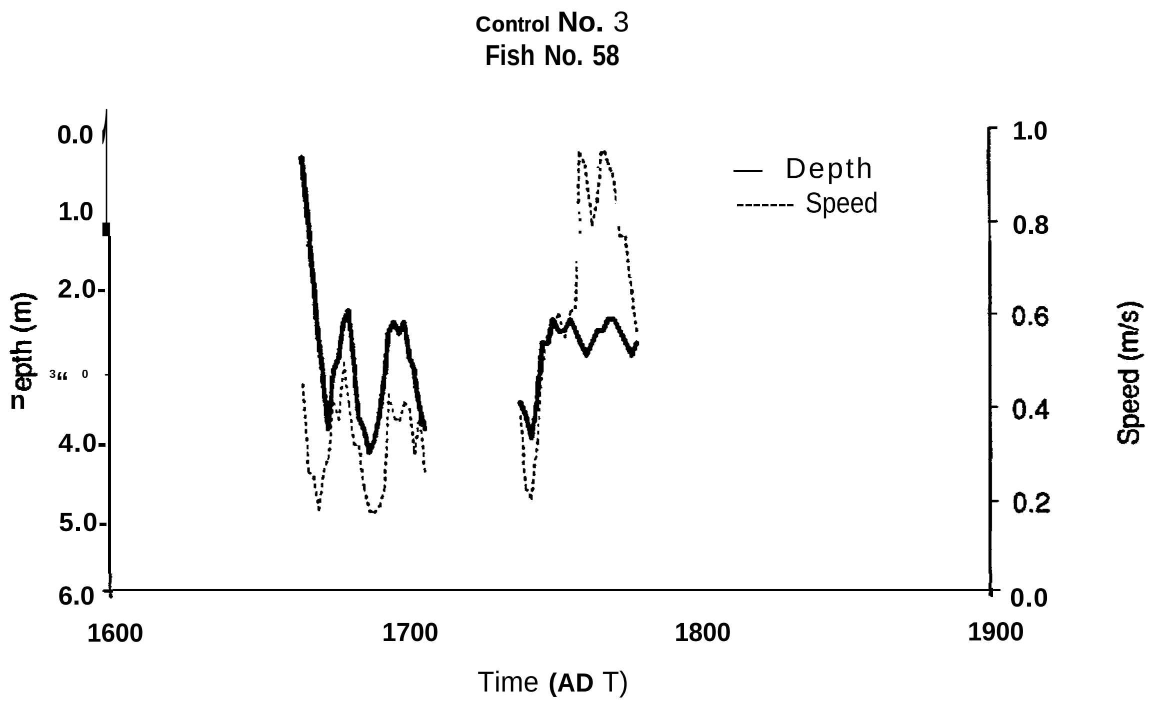


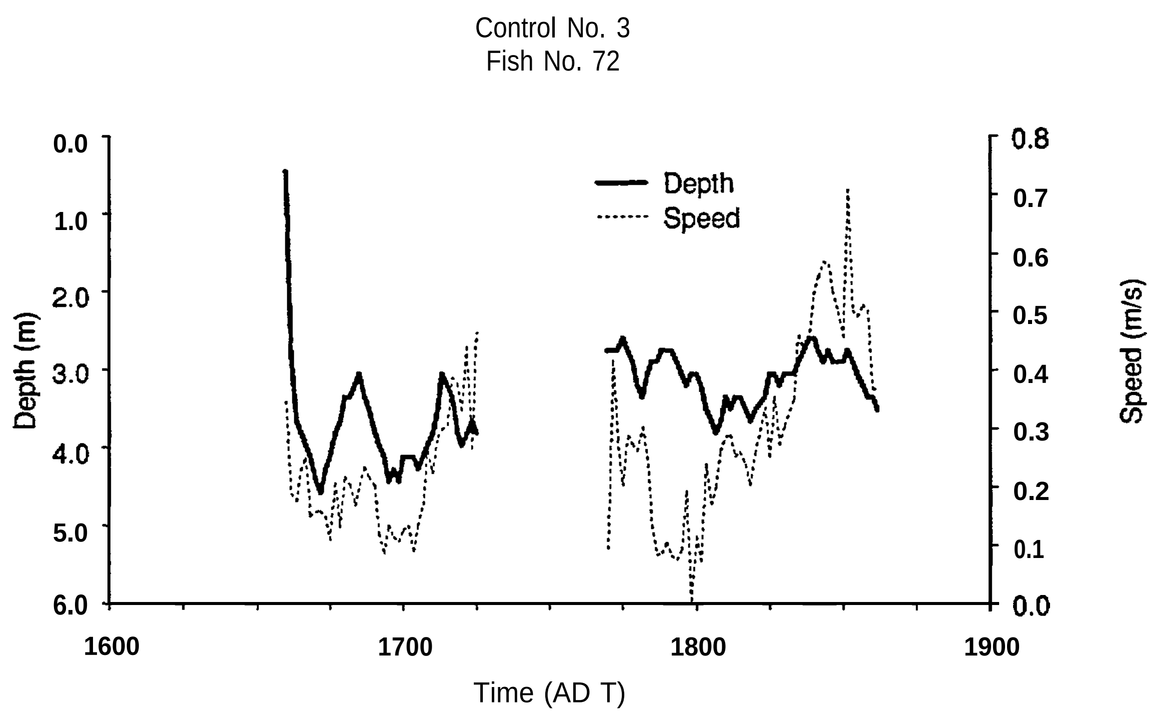
Control No. 2
Fish No. 39



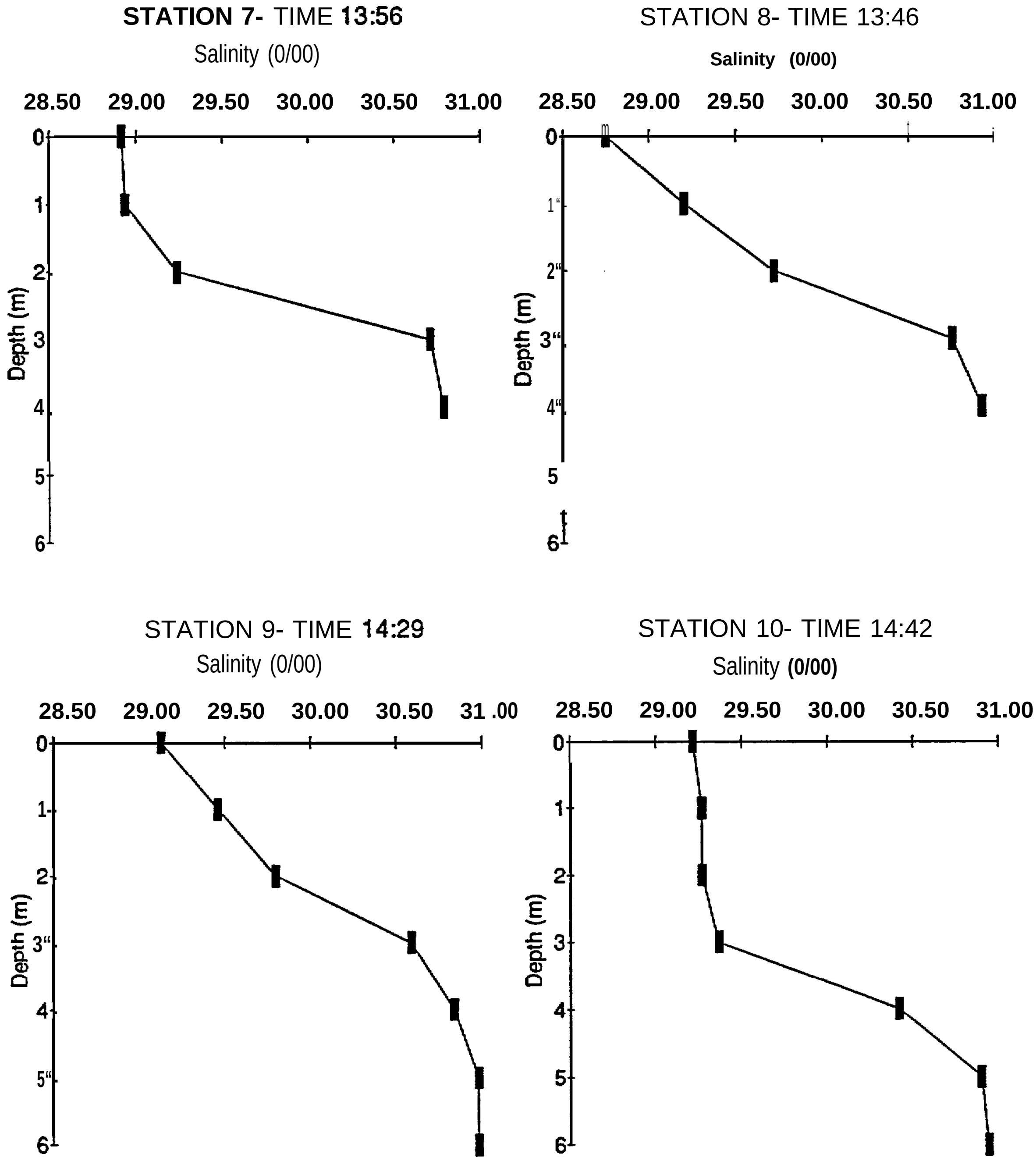
Depth and Ground Speed Versus Time for Fish Numbers 34 and 39 During Control 2

Figure 3-18

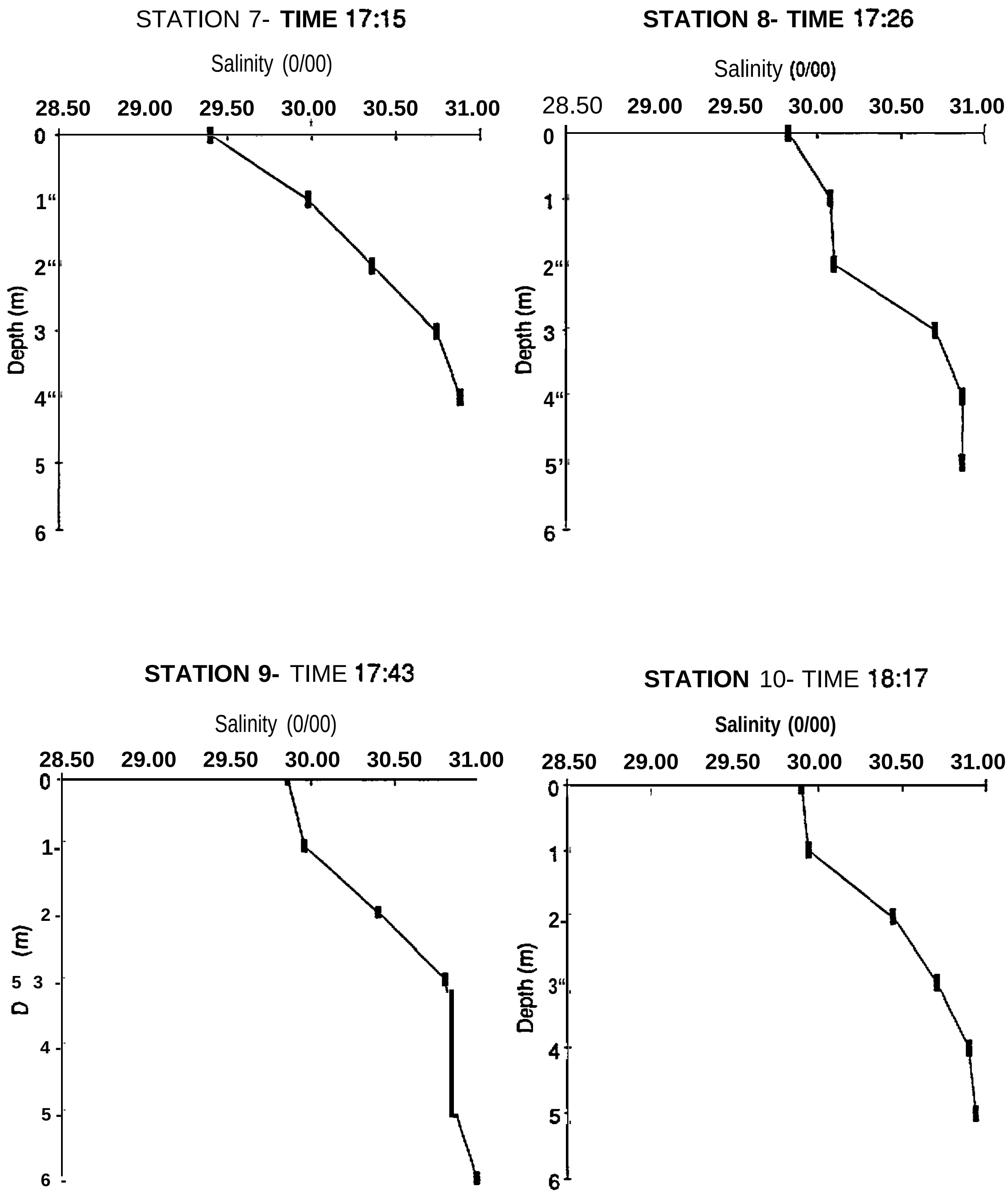




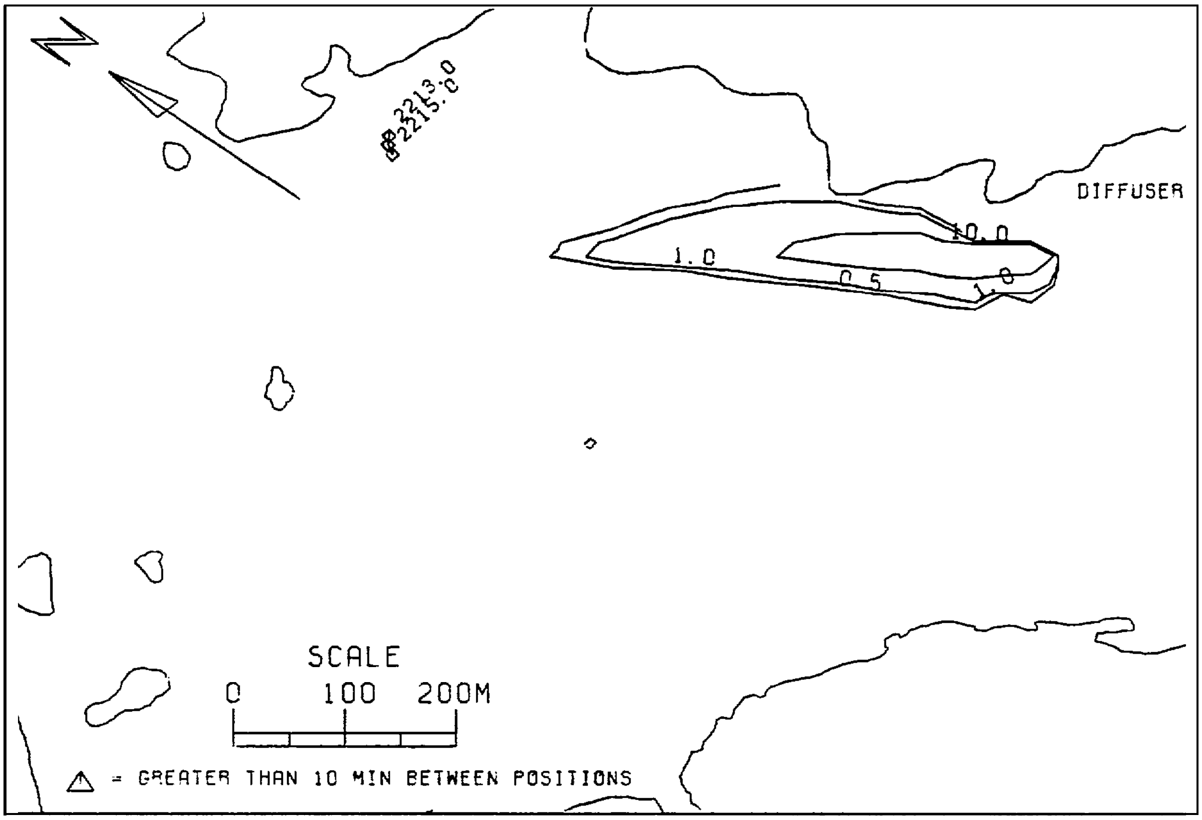
Depth and Ground Speed Versus Time for Fish Numbers 58 and 72 During Control 3
Figure 3-19



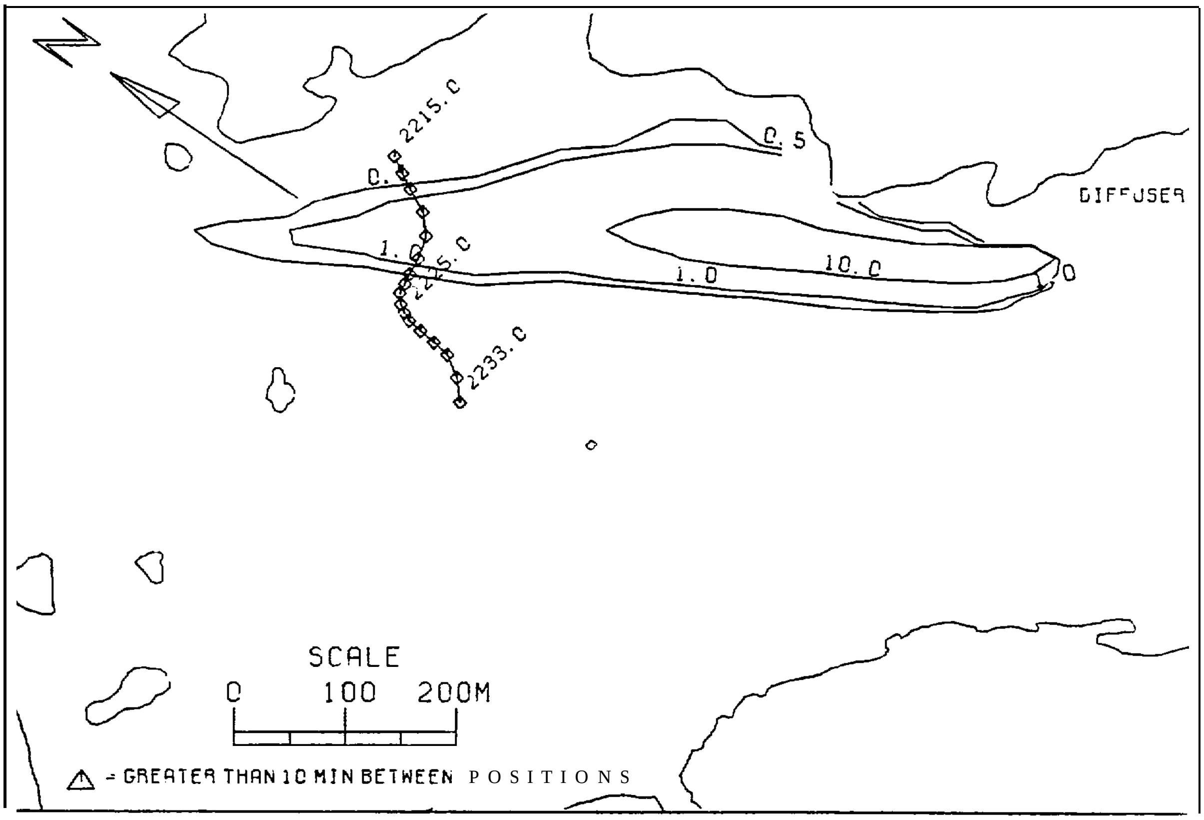
Salinity Profile with Depth for Control 2
Figure 3-20



Salinity Profile with Depth for Control 3
Figure 3-21



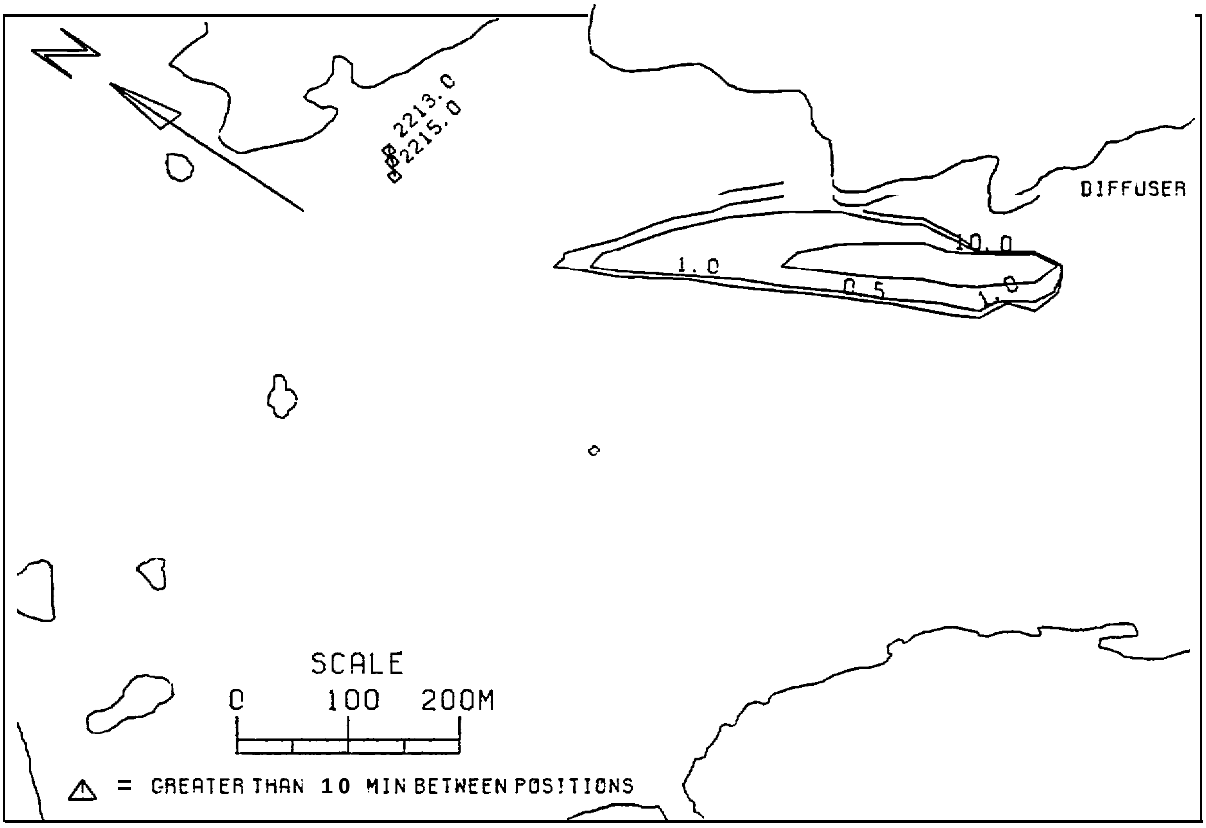
FISH 19, TREATMENT NO. 1, PLUME AT 22:00



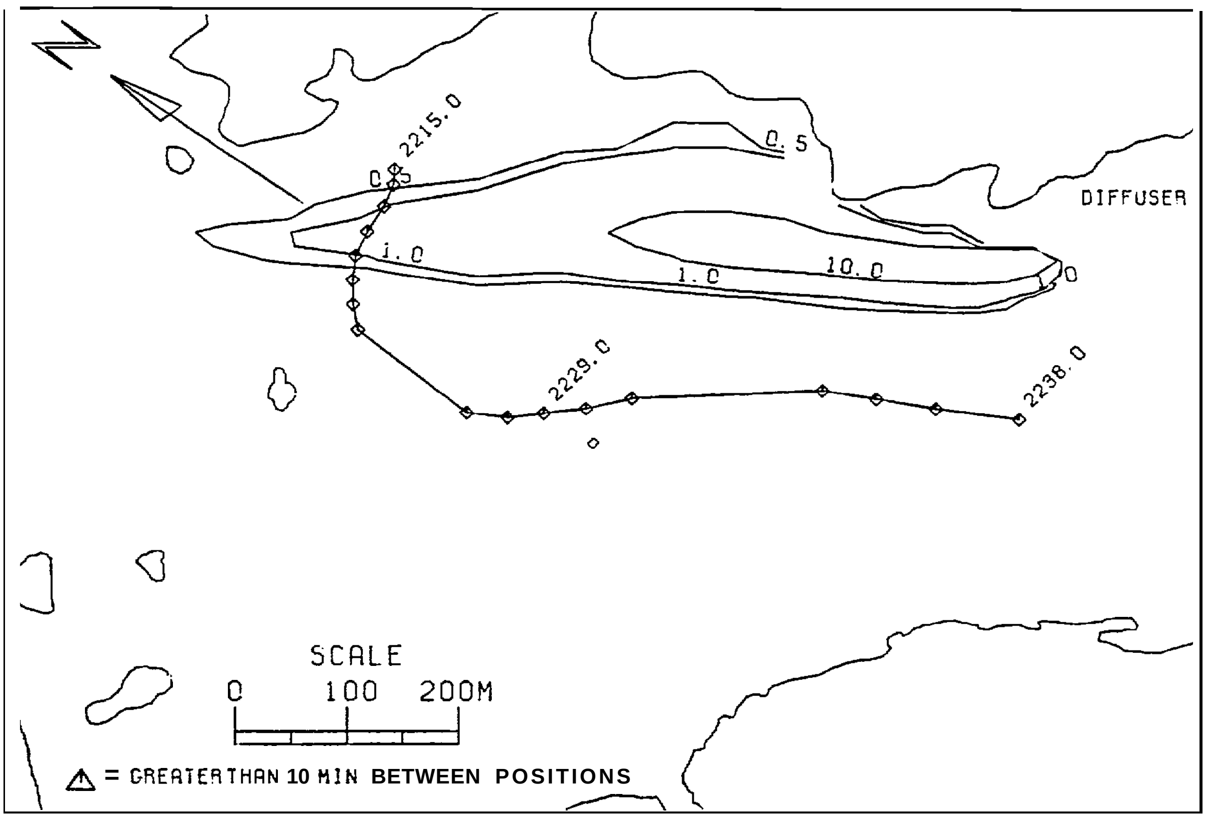
FISH 19, TREATMENT NO. 1, PLUME AT 22:30

Horizontal Movements of Fish Number 19 and Plume Trajectories at Time Intervals During Treatment 1

Figure 3-22

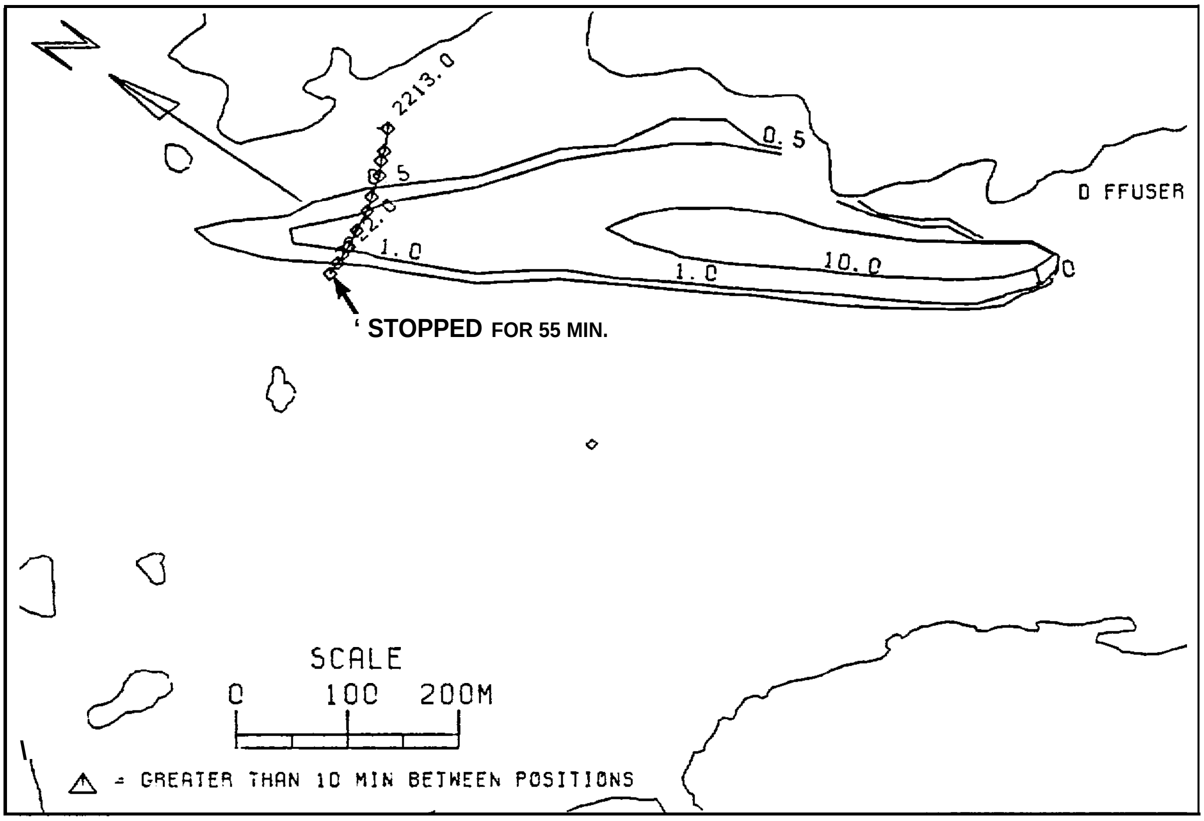


FISH 18, TREATMENT NO. 1, PLUME AT 22:00

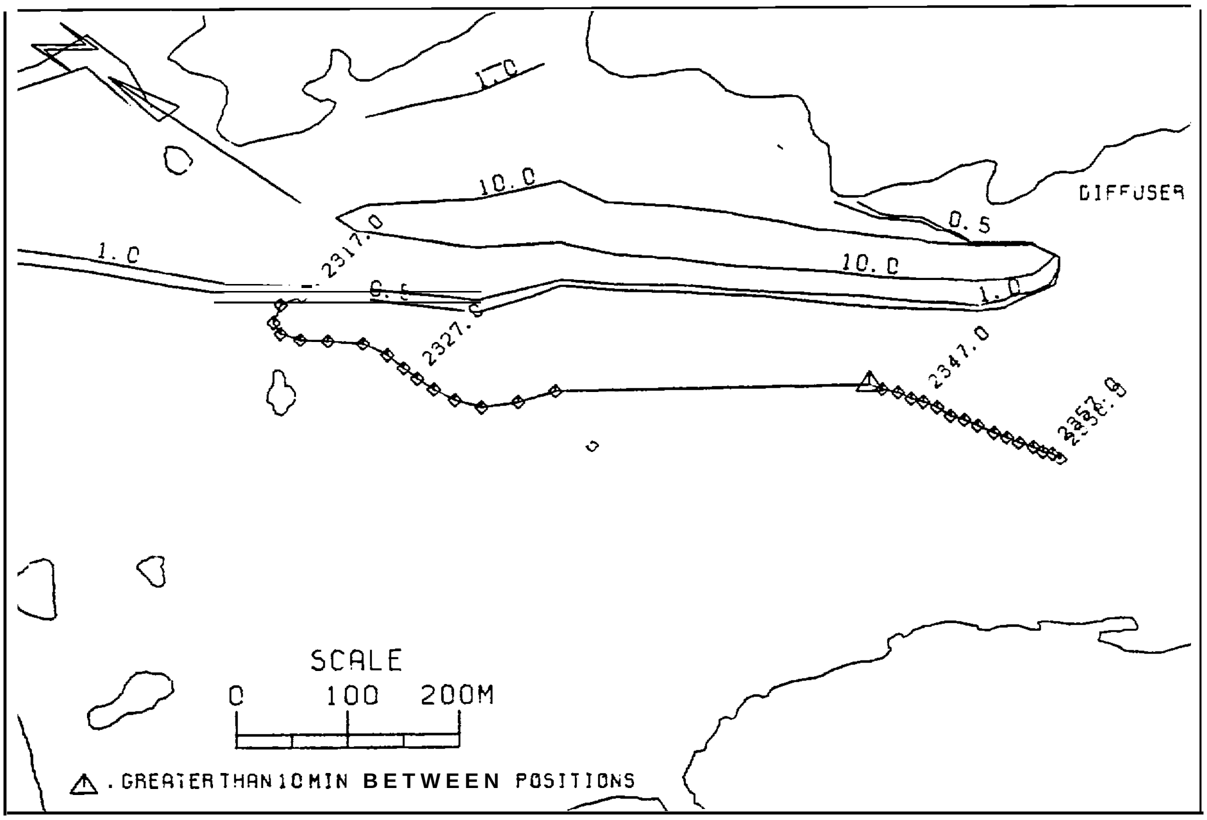


FISH 18, TREATMENT NO. 1, PLUME AT 22:30

Horizontal Movements of Fish Number 18 and Plume Trajectories at Time intervals During Treatment
Figure 3-23



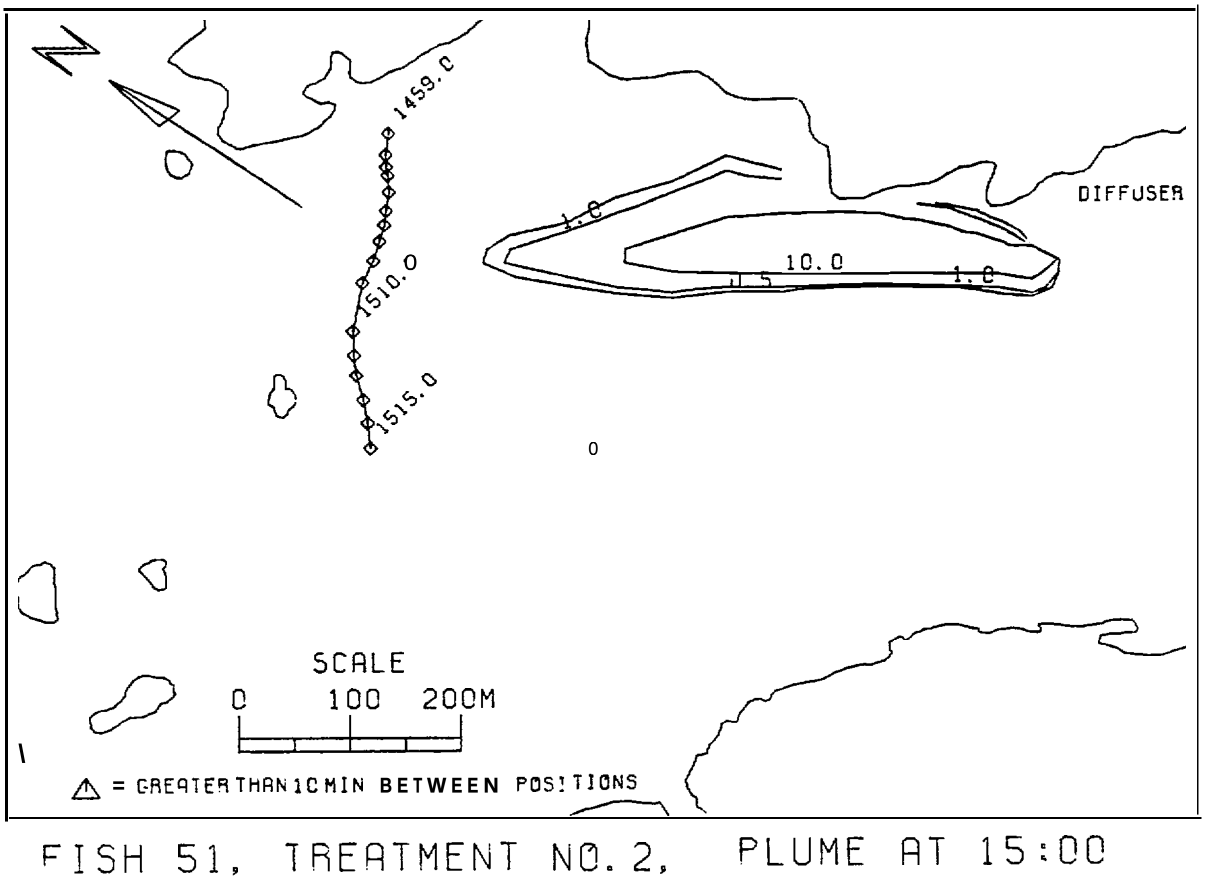
FISH 14. TREATMENT NO. 1, PLUME AT 22:30



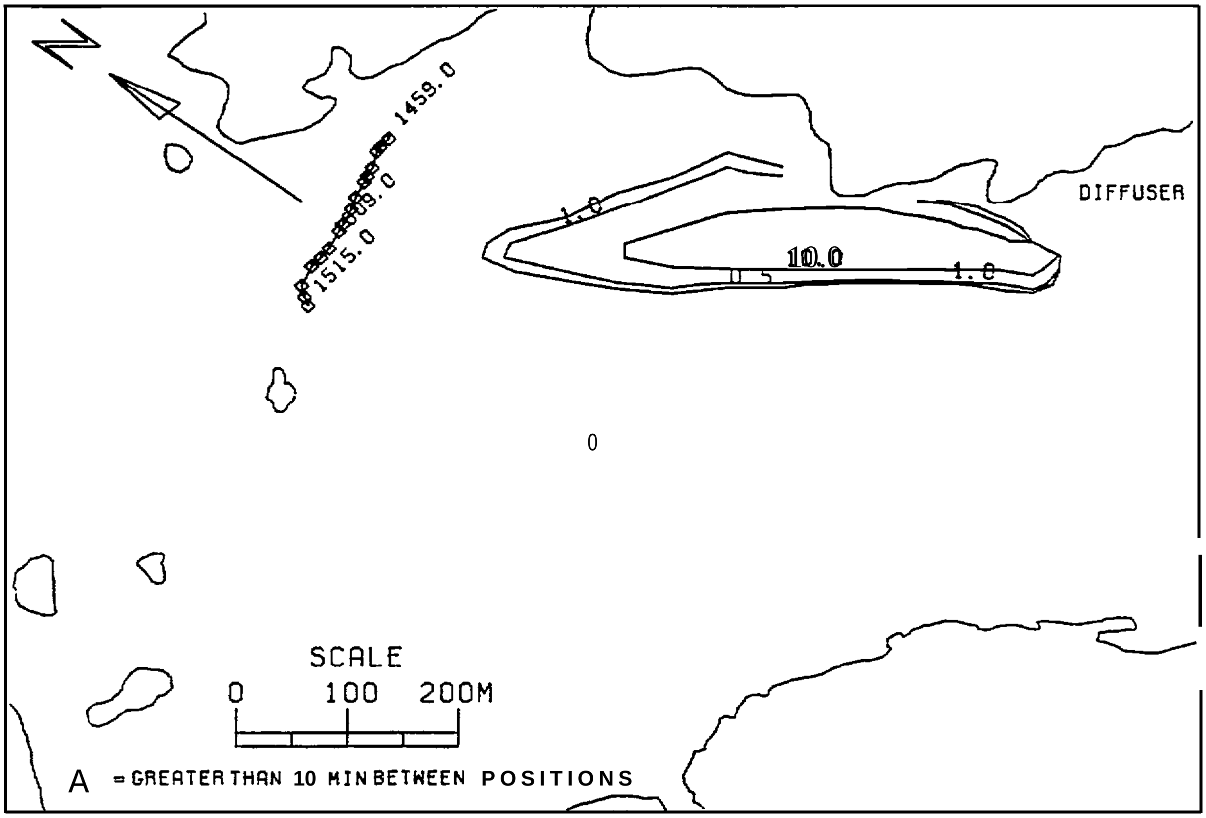
FISH 14. TREATMENT NO. 1, PLUME AT 23:30

Horizontal Movements of Fish Number 14 and Plume Trajectories at Time Intervals During Treatment 1

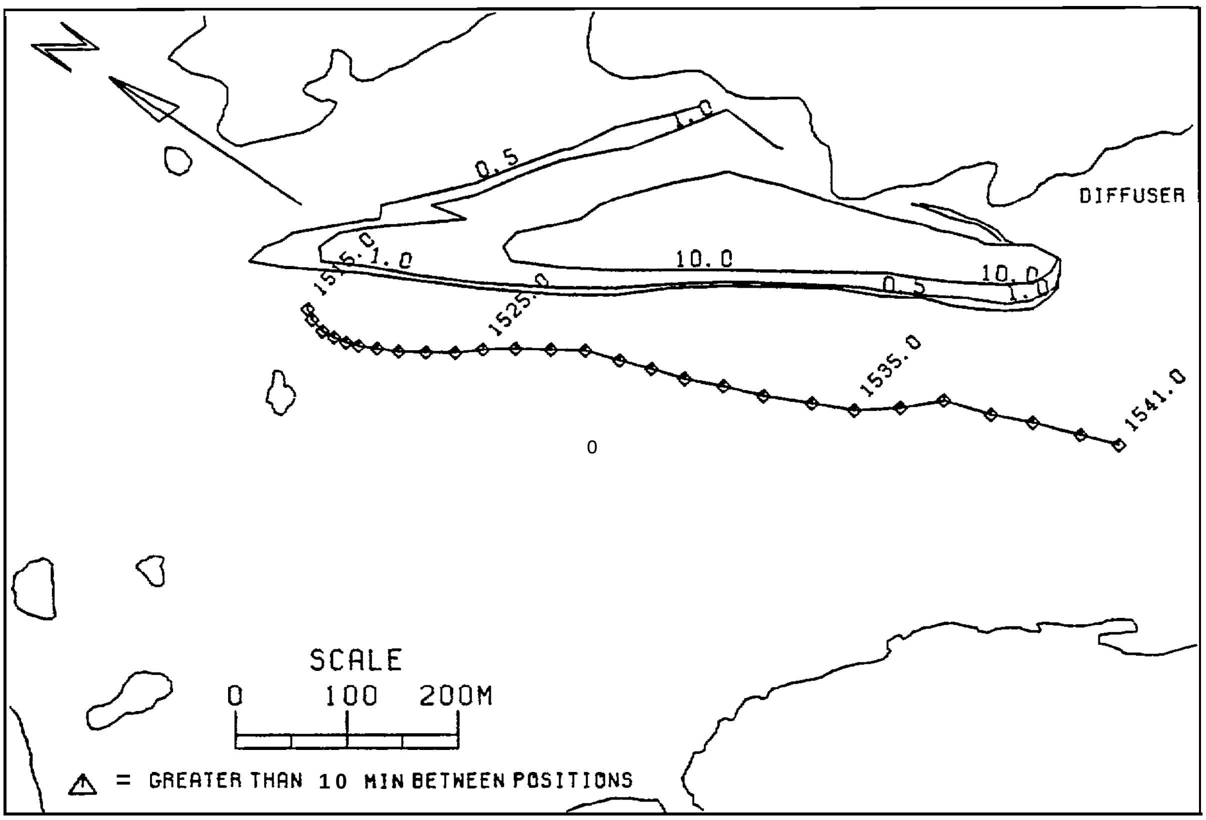
Figure 3-24



Horizontal Movements of Fish Number 51 and Plume Trajectories at
Time Intervals During Treatment 2
Figure 3-25

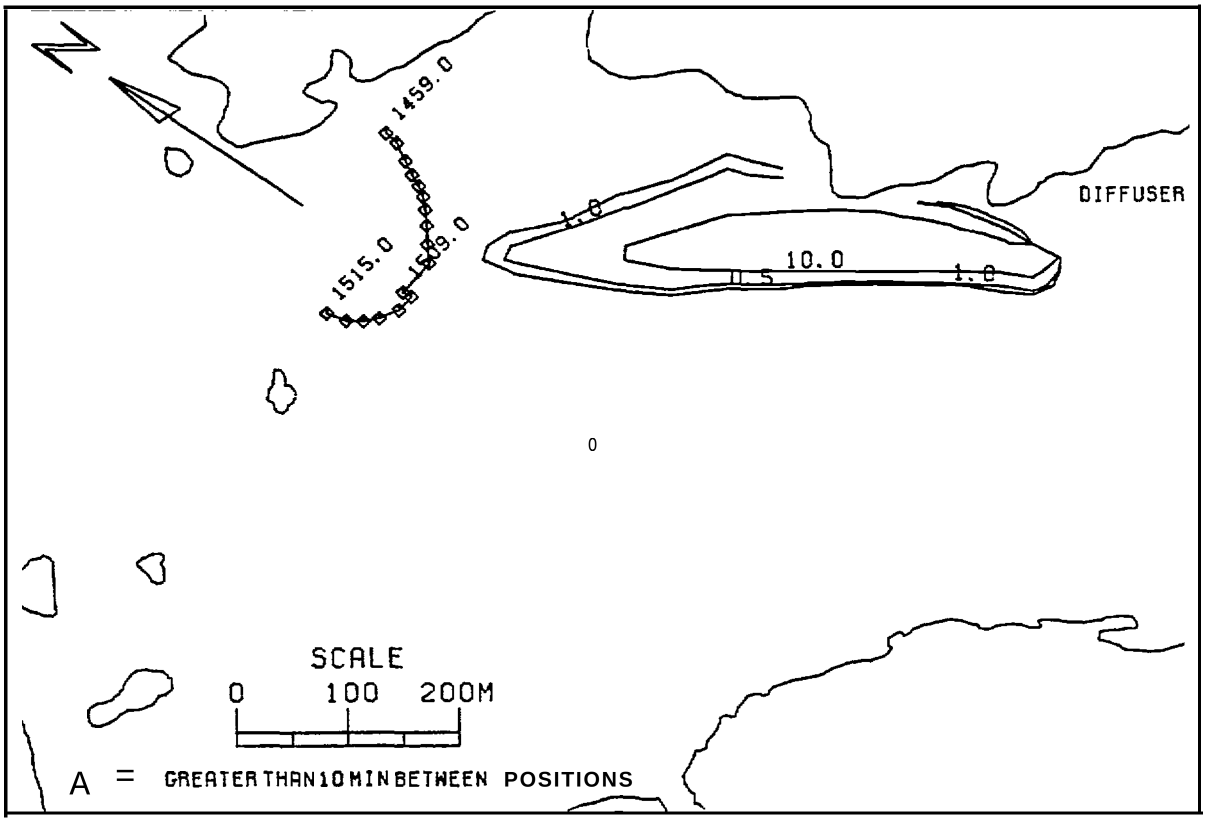


FISH 52, TREATMENT NO. 2, PLUME AT 15:00

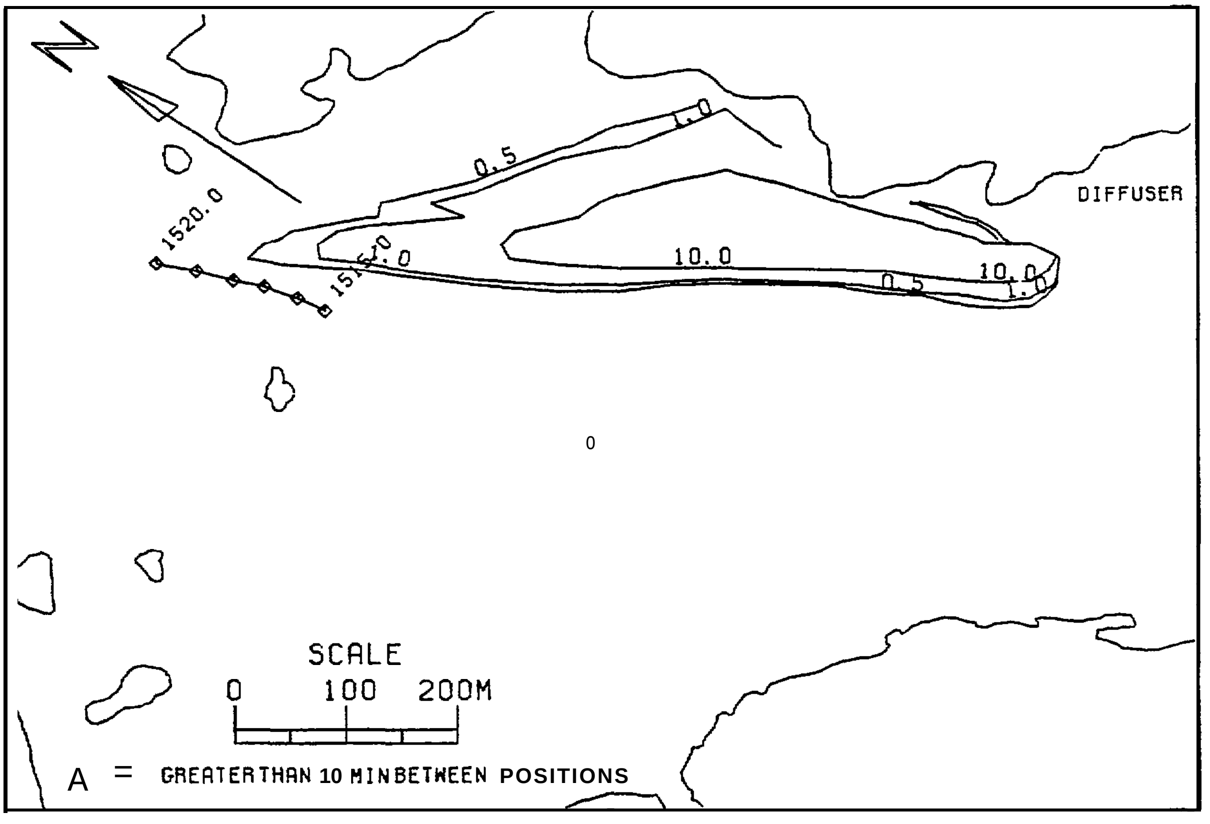


FISH 52, TREATMENT NO. 2, PLUME AT 15:30

Horizontal Movements of Fish Number 52 and Plume Trajectories at Time Intervals During Treatment2
Figure 3-26

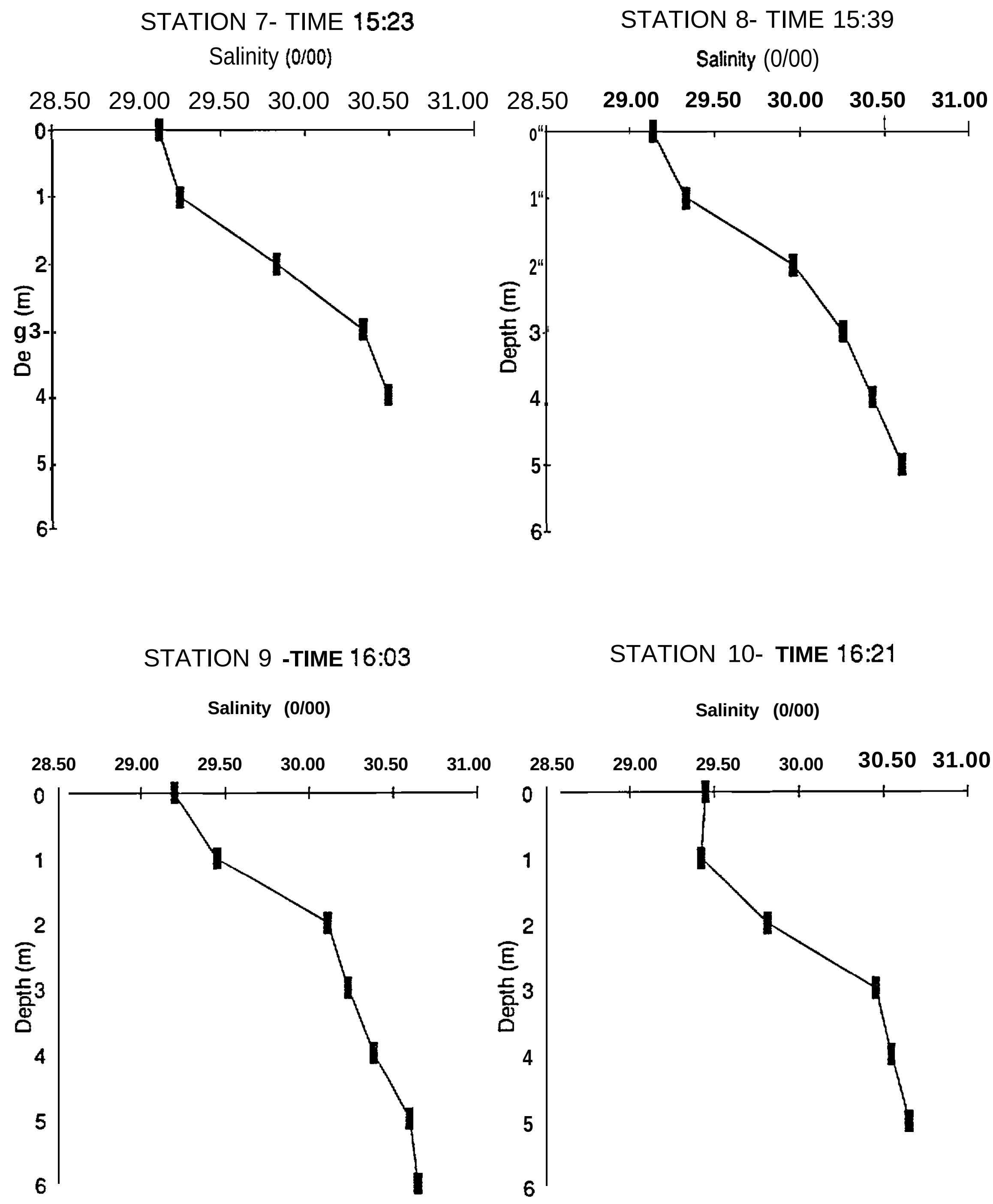


FISH 48, TREATMENT NO. 2, PLUME AT 15:00

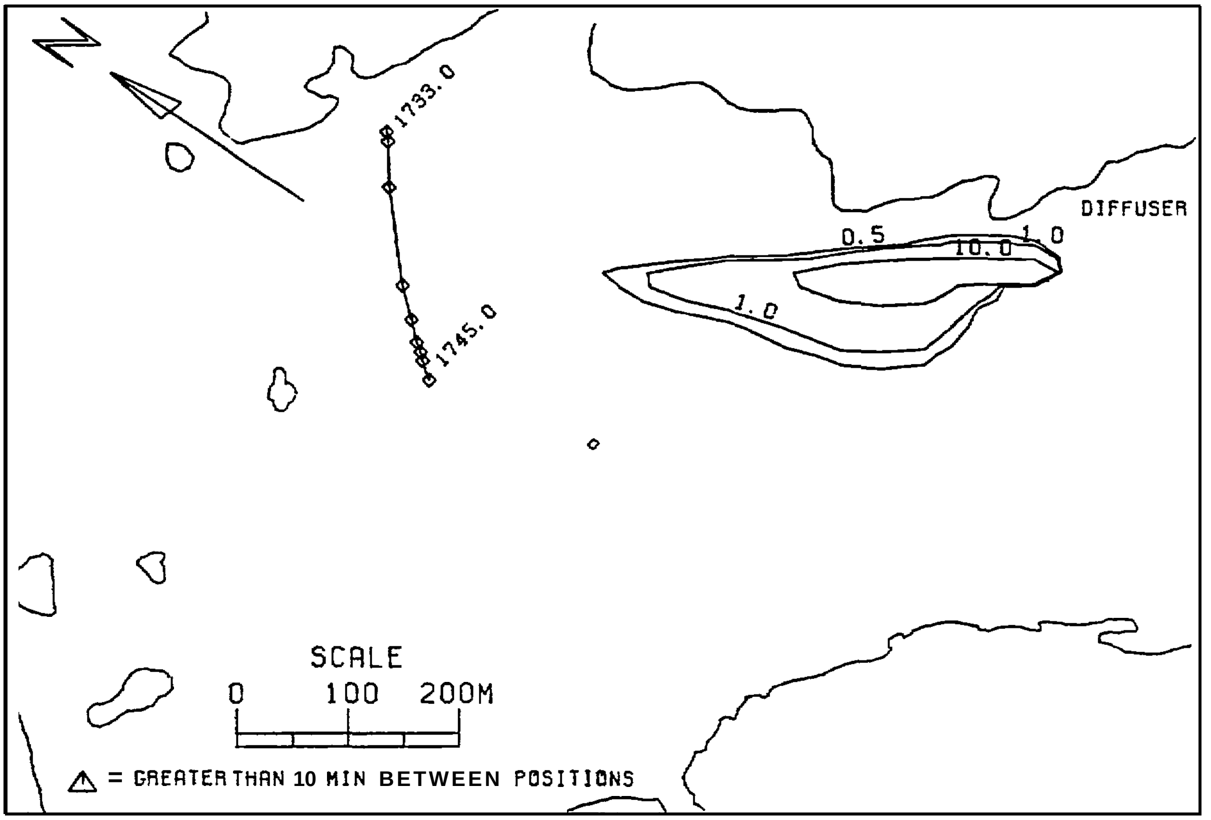


FISH 48, TREATMENT NO. 2, PLUME AT 15:30

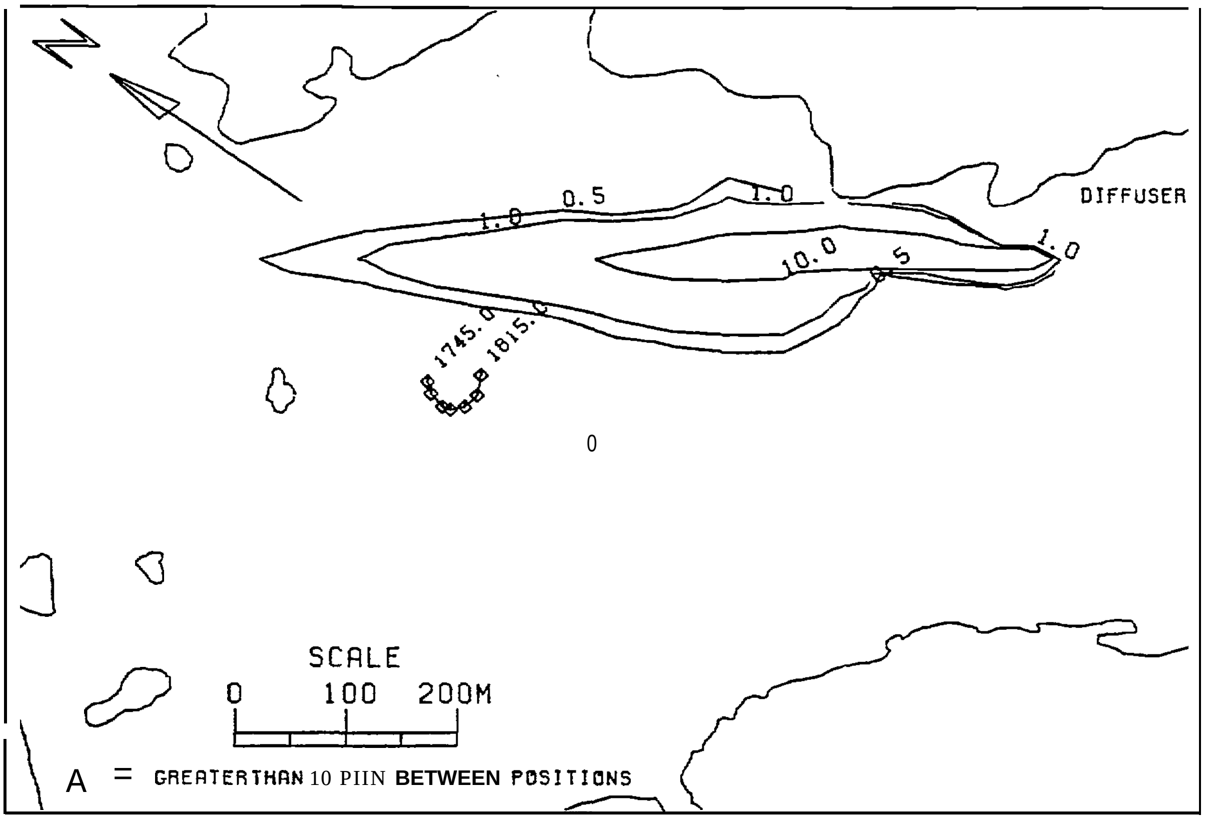
Horizontal Movements of Fish Number 48 and Plume Trajectories at Time Intervals During Treatment 2
Figure 3-27



Salinity Profile with Depth for Treatment 2
Figure 3-28



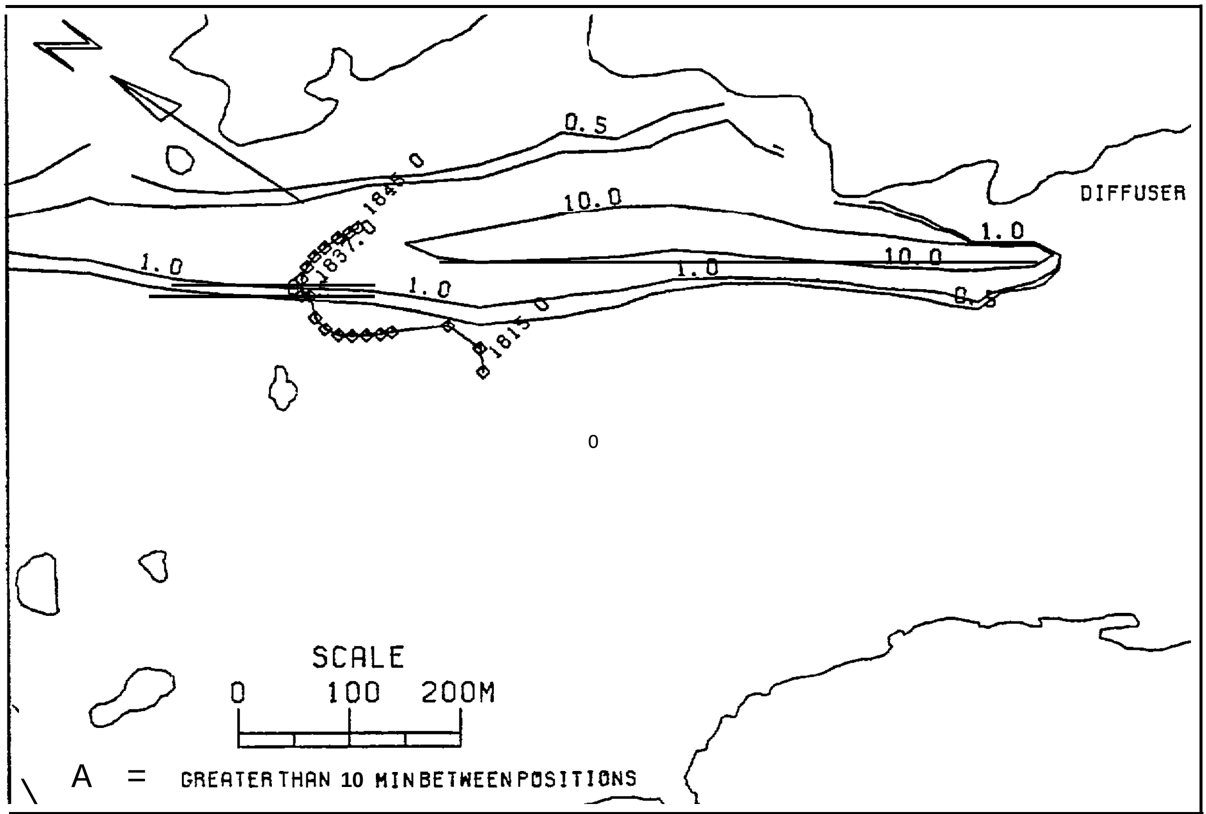
FISH 73, TREATMENT NO. 3, PLUME AT 17:30



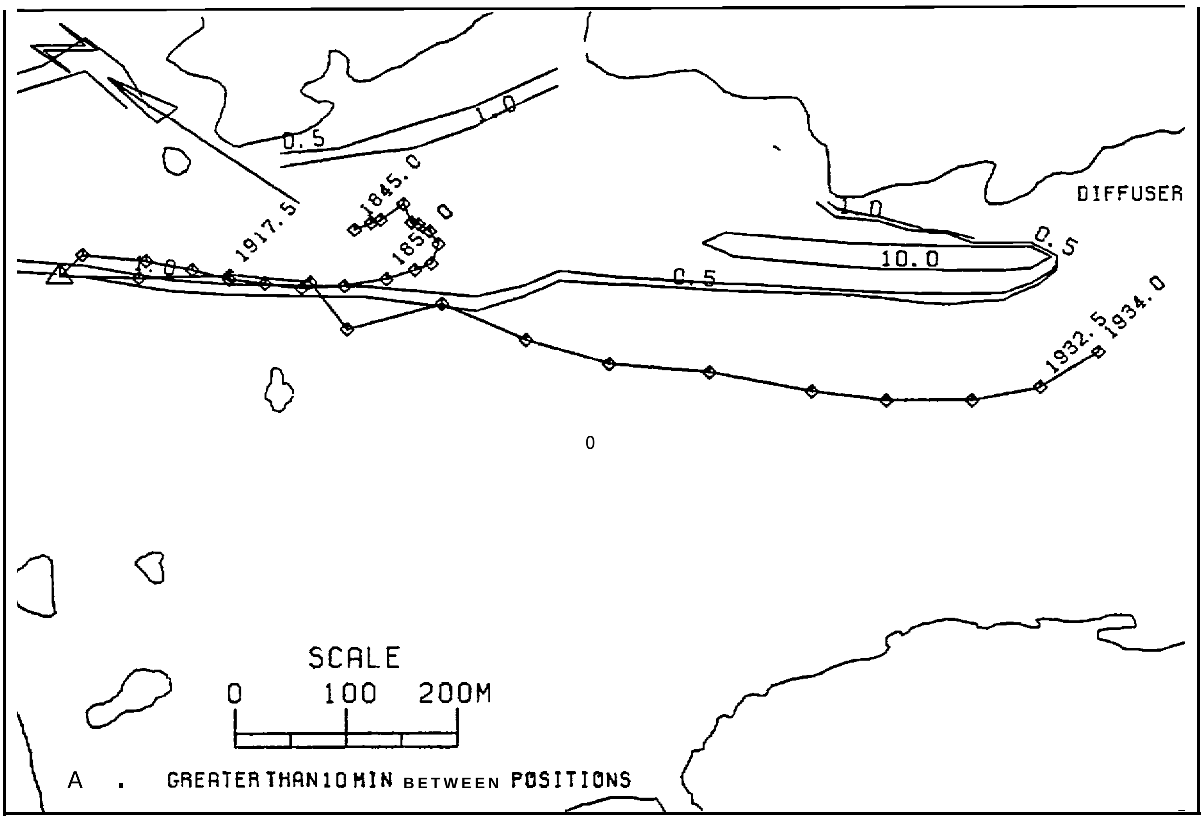
FISH 73, TREATMENT NO. 3, PLUME AT 18:00

Horizontal Movements of Fish Number 73 and Plume Trajectories at Time Intervals During Treatment 3

Figure 3-29



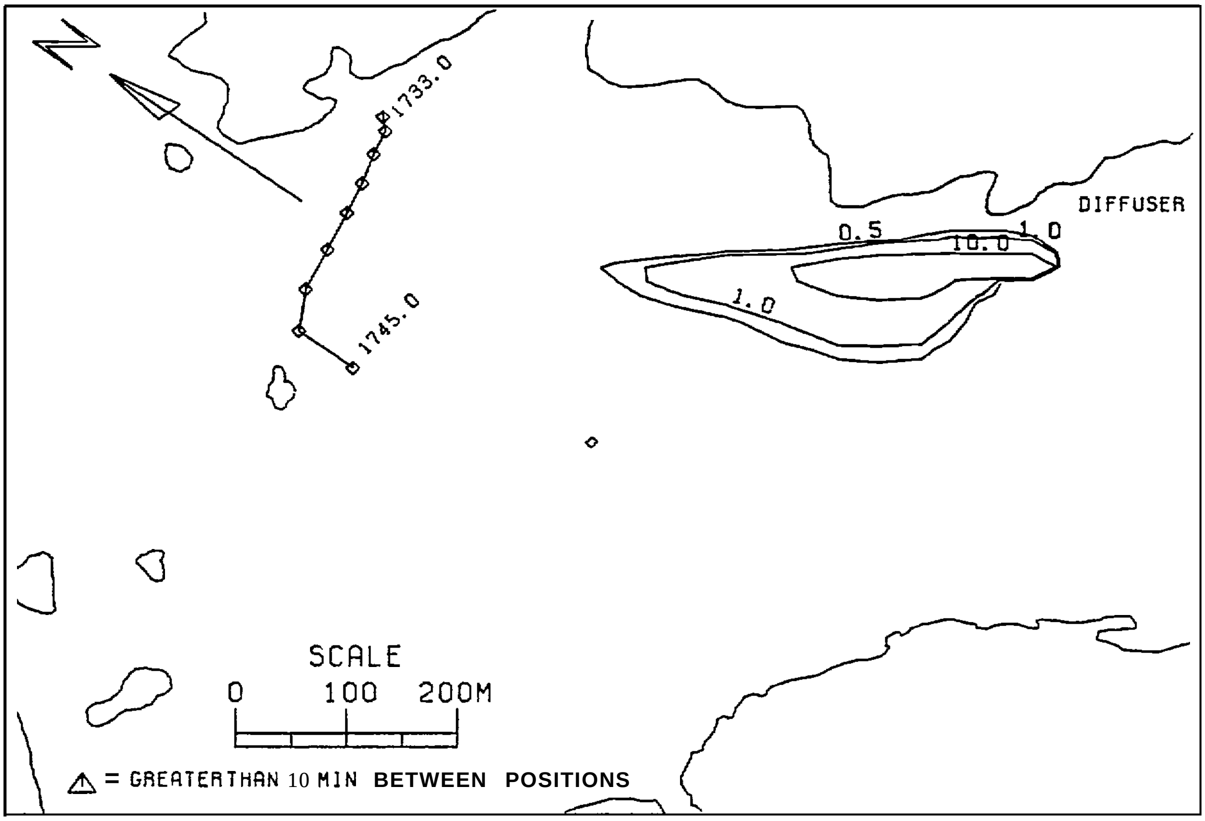
FISH 73, TREATMENT NO. 3, PLUME AT 18:30



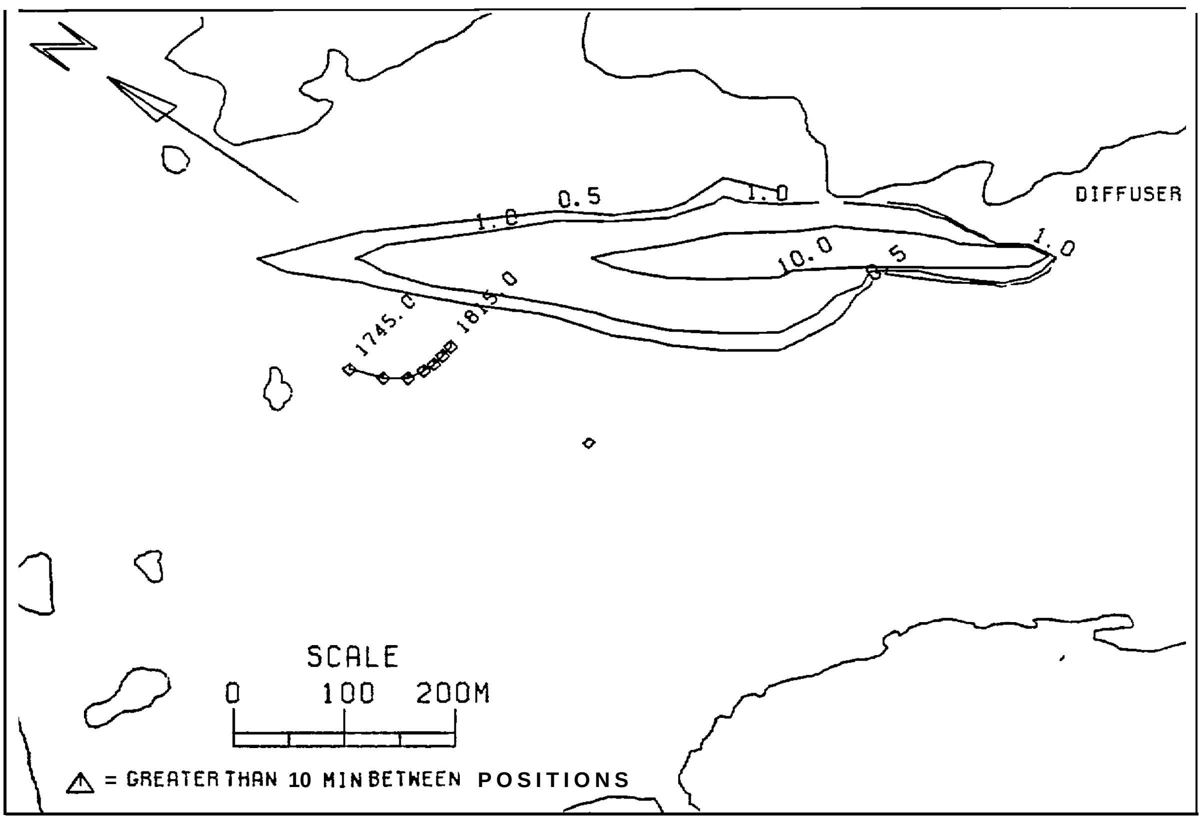
FISH 73, TREATMENT NO. 3, PLUME AT 19:00

Horizontal Movements of Fish Number 73 and Plume Trajectories at Time Intervals During Treatment 3

Figure 3-29 (continued)



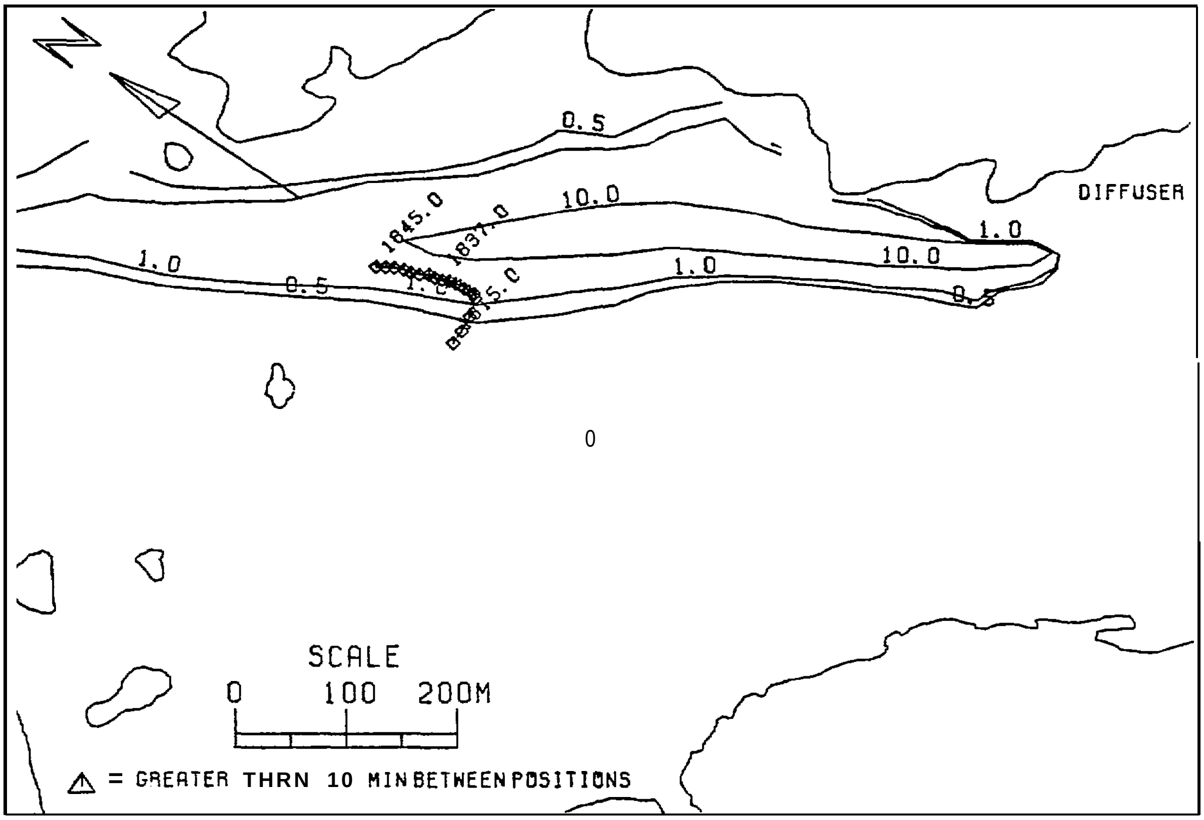
FISH 88, TREATMENT NO. 3, PLUME AT 17:30



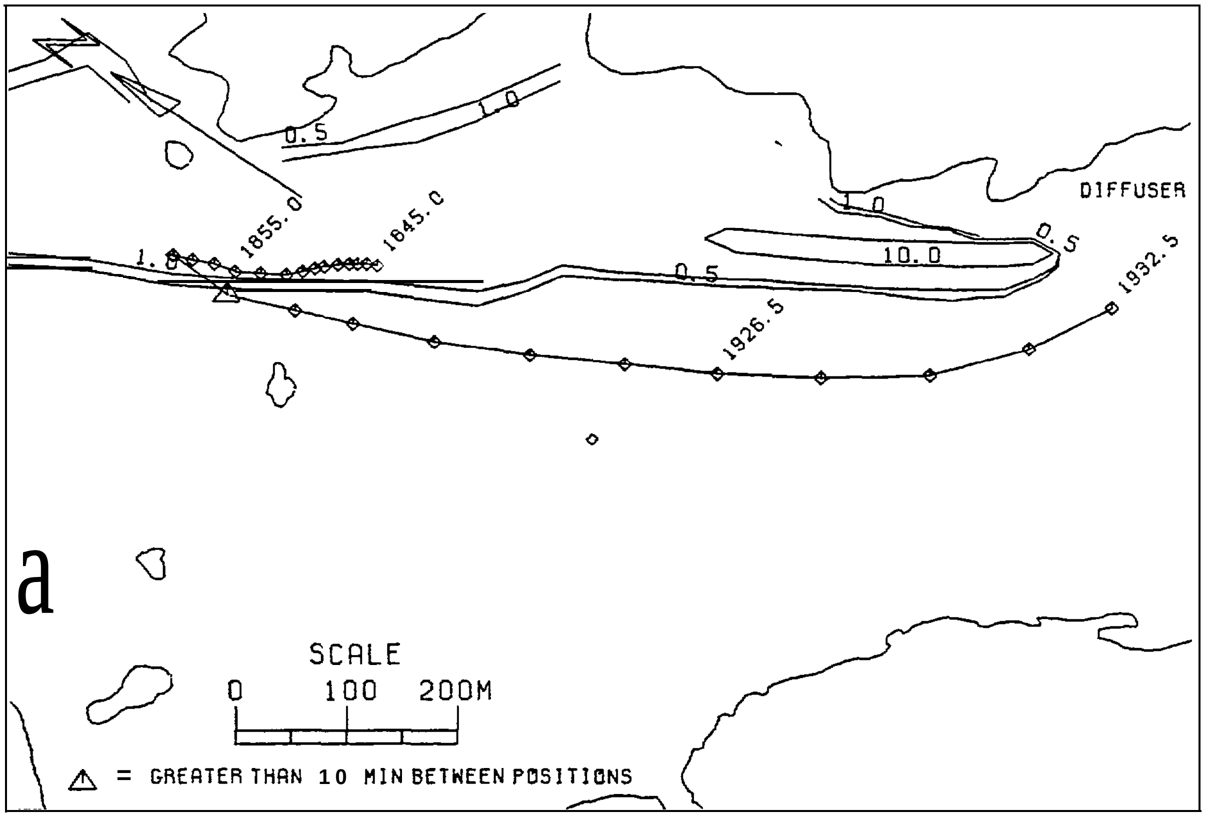
FISH 88, TREATMENT NO. 3, PLUME AT 18:00

Horizontal Movements of Fish Number 88 and Plume Trajectories at Time Intervals During Treatment 3

Figure 3-30



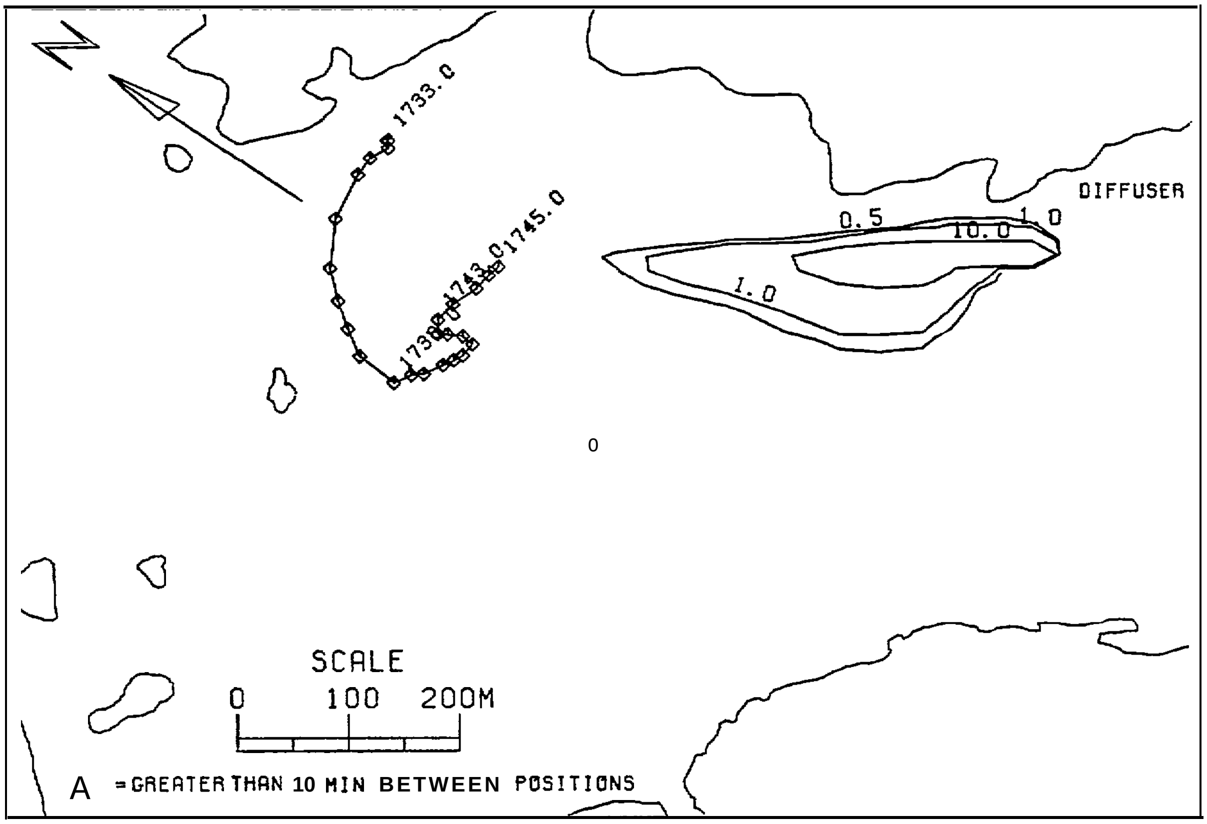
FISH 88, TREATMENT NO. 3, PLUME AT 18:30



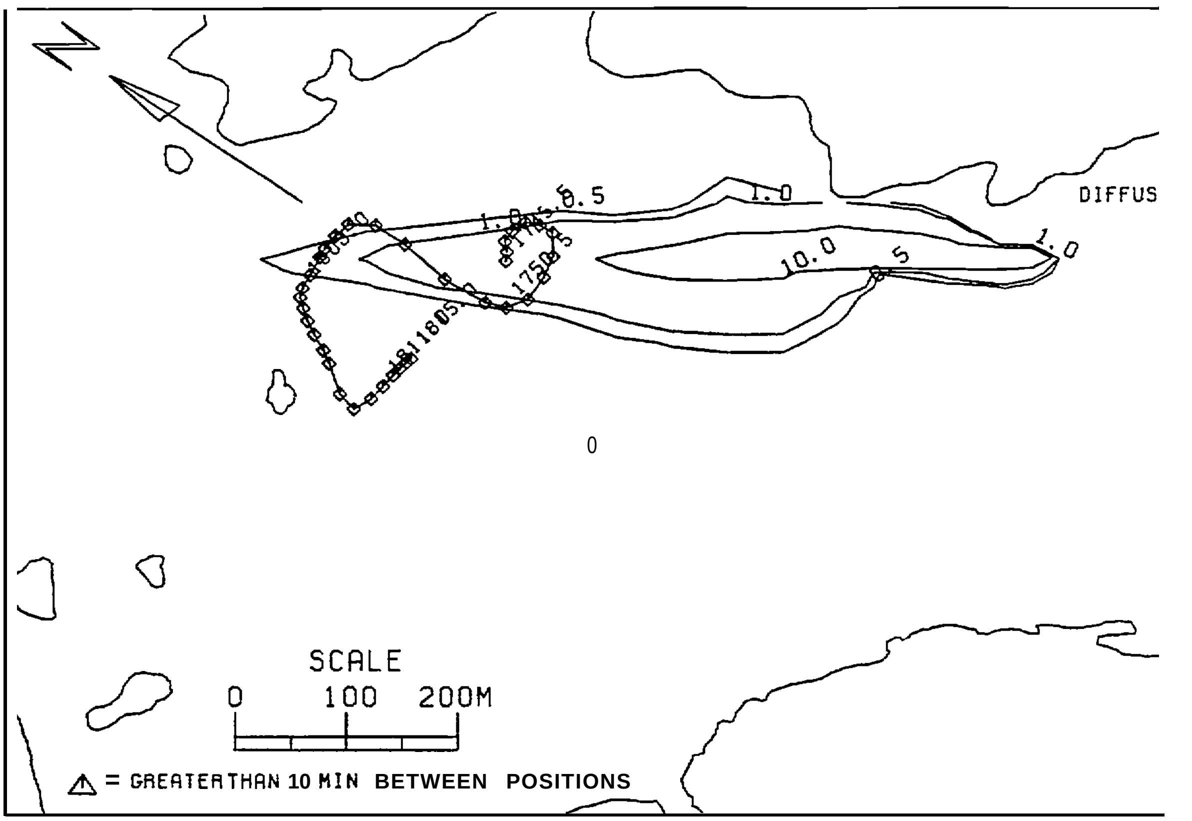
FISH 88, TREATMENT NO. 3, PLUME AT 19:00

Horizontal Movements of Fish Number 88 and Plume Trajectories at Time Intervals During Treatment3

Figure 3-30 (continued)

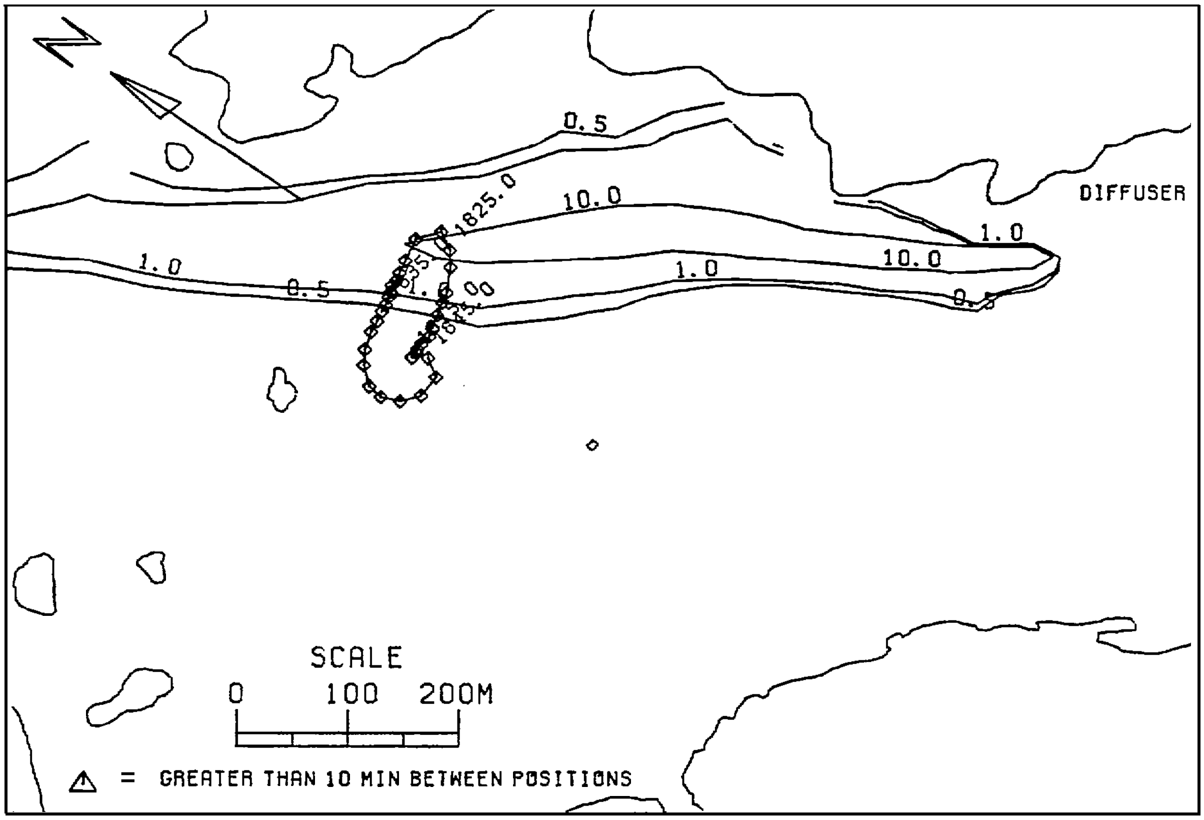


FISH 83, TREATMENT NO. 3, PLUME AT 17:30

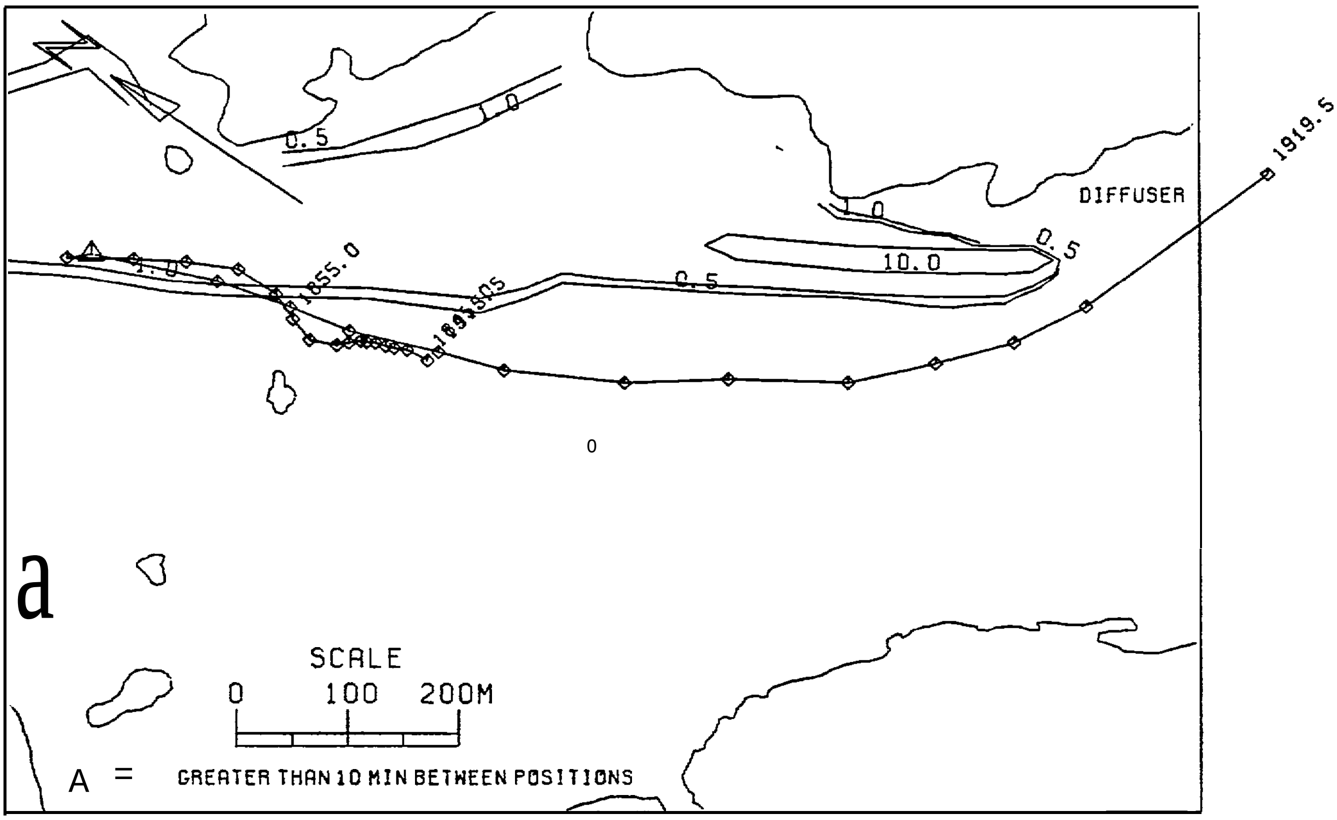


FISH 83, TREATMENT NO. 3, PLUME AT 18:00

Horizontal Movements of Fish Number 83 and Plume Trajectories at Time Intervals During Treatment 3
Figure 3-31

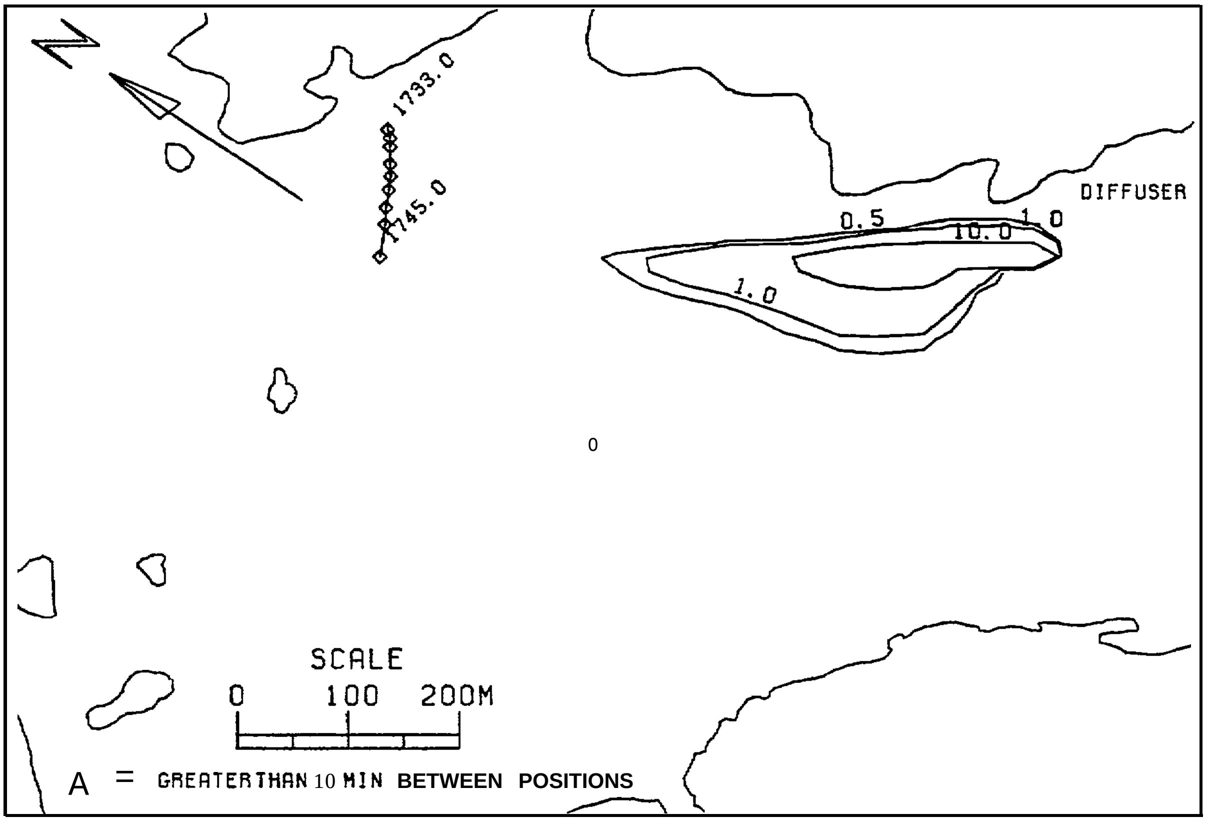


FISH 83, TREATMENT NO. 3, PLUME AT 18:30

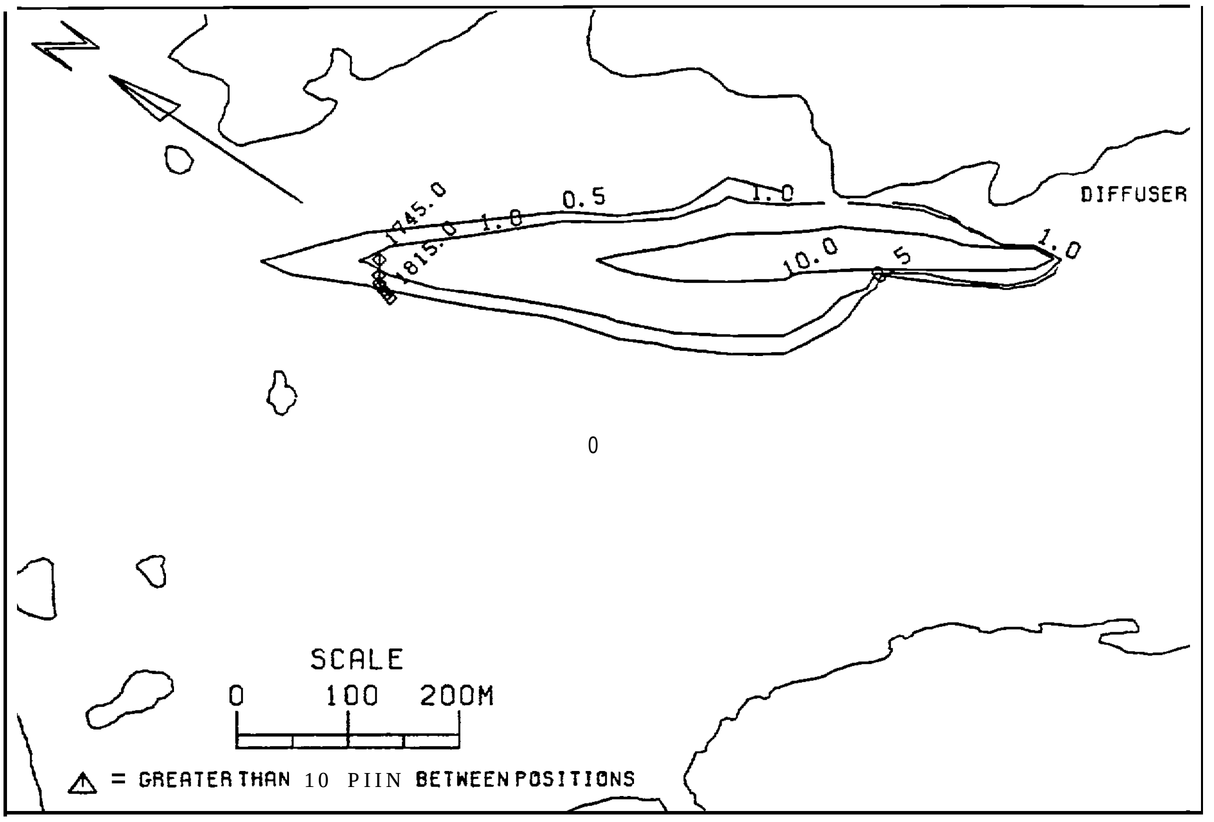


FISH 83, TREATMENT NO. 3, PLUME AT 19:00

Horizontal Movements of Fish Number 83 and Plume Trajectories at Time intervals During Treatment 3
Figure 3-31 (continued)



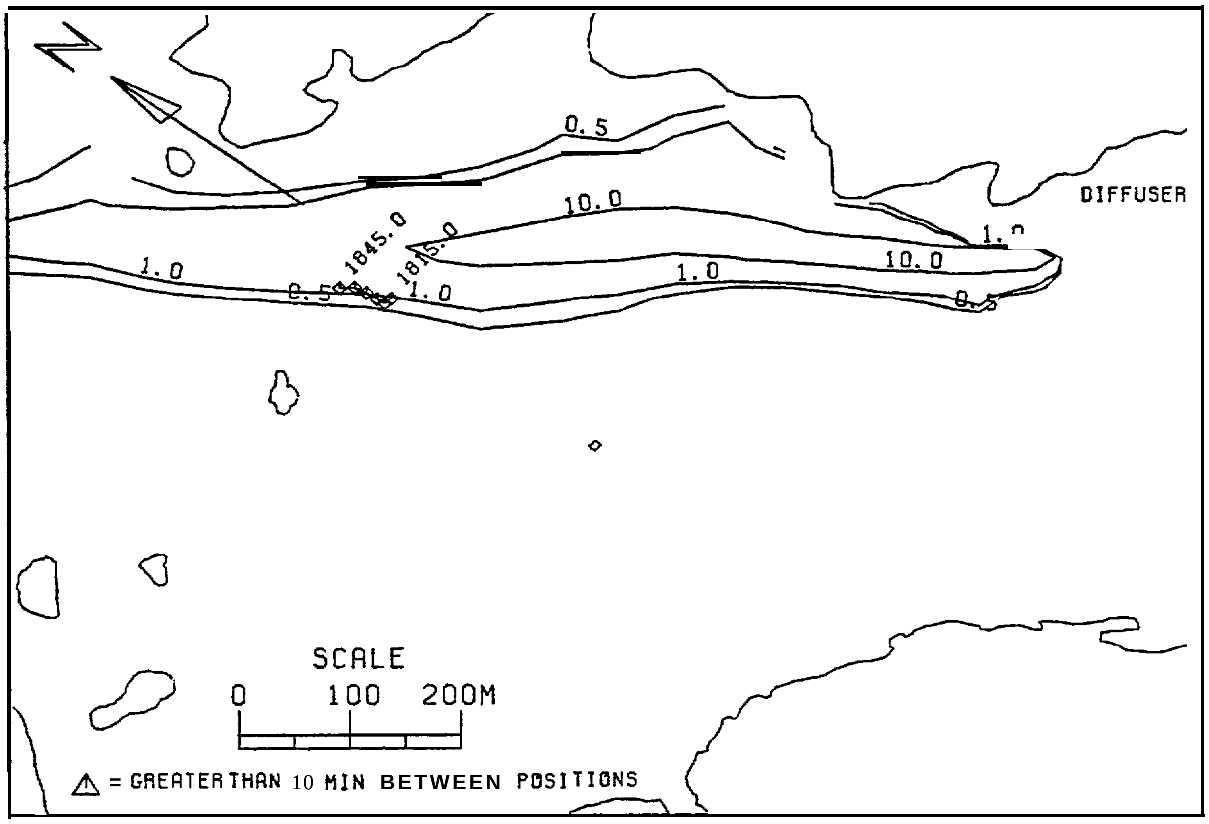
FISH 77, TREATMENT NO. 3, PLUME AT 17:30



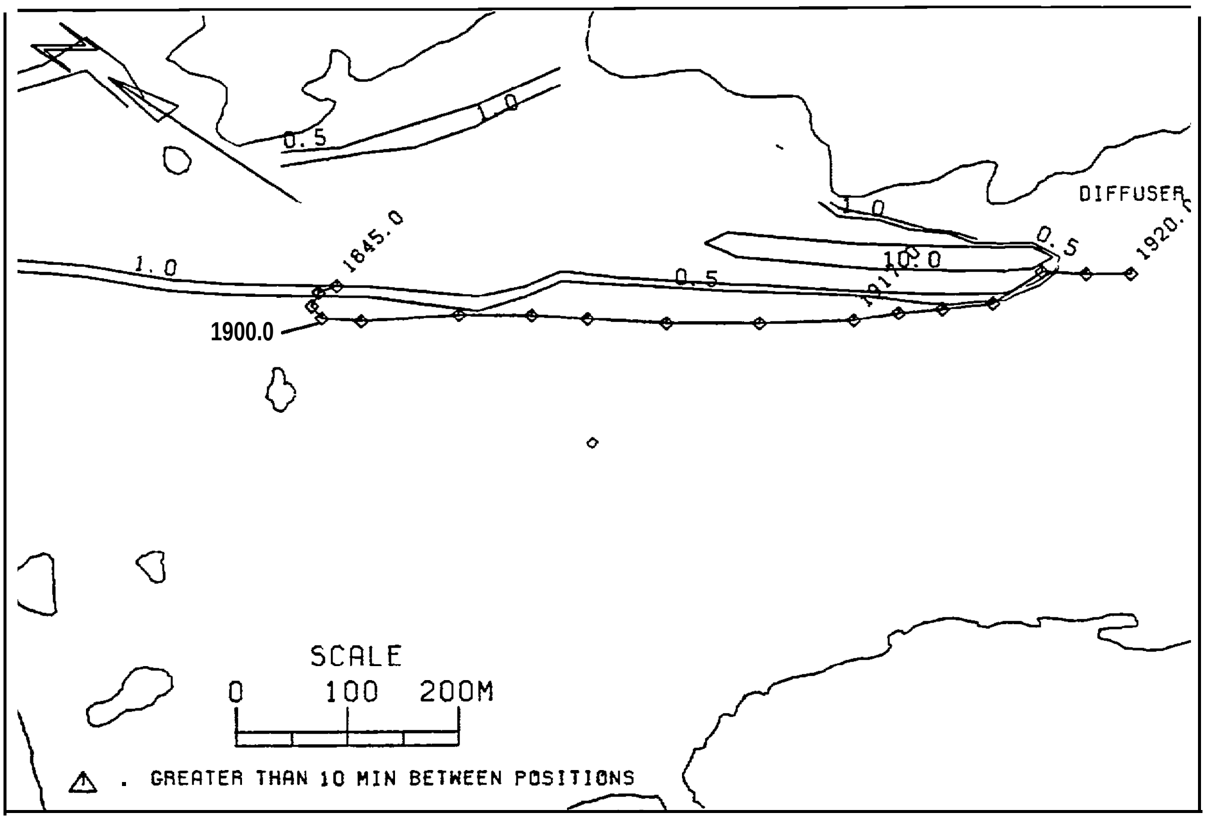
FISH 77. TREATMENT NO. 3, PLUME AT 18:00

Horizontal Movements of Fish Number 77 and Plume Trajectories at Time Intervals During Treatment 3

Figure 3-32

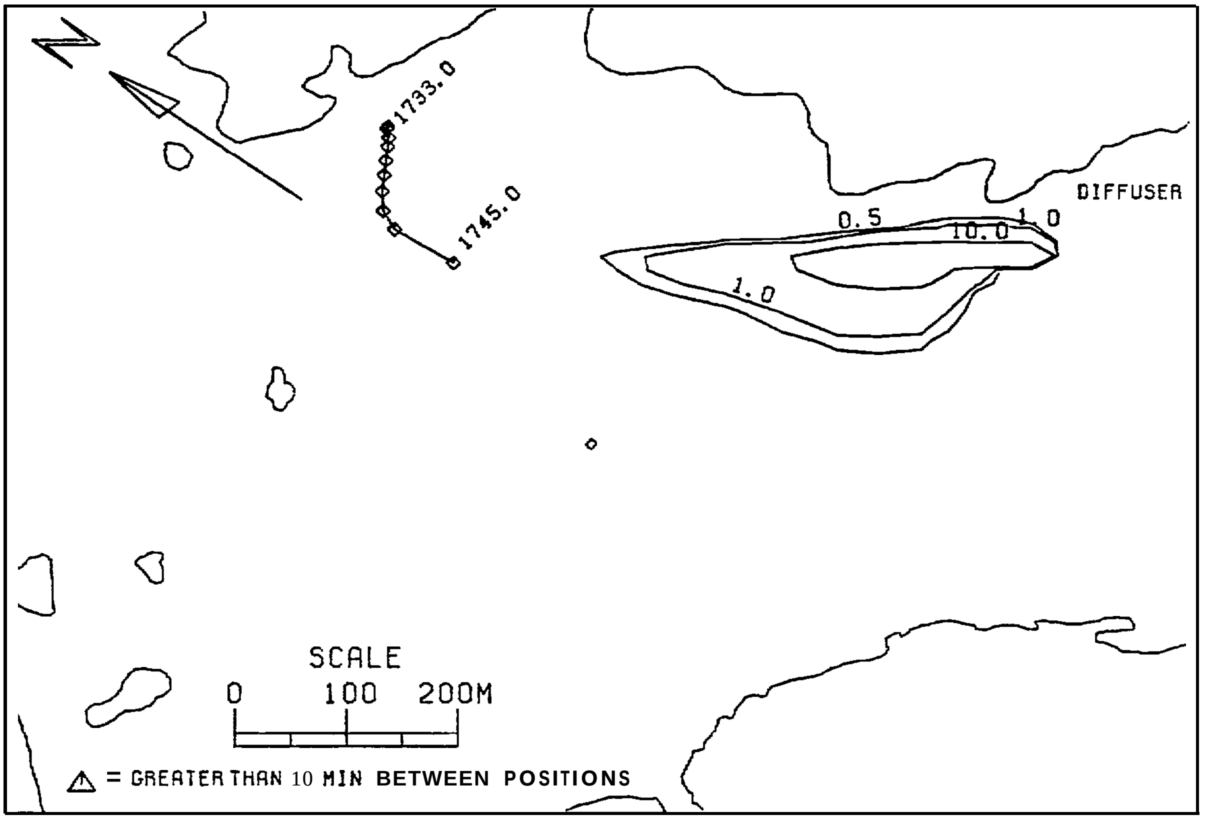


FISH 77, TREATMENT NO. 3, PLUME AT 18:30

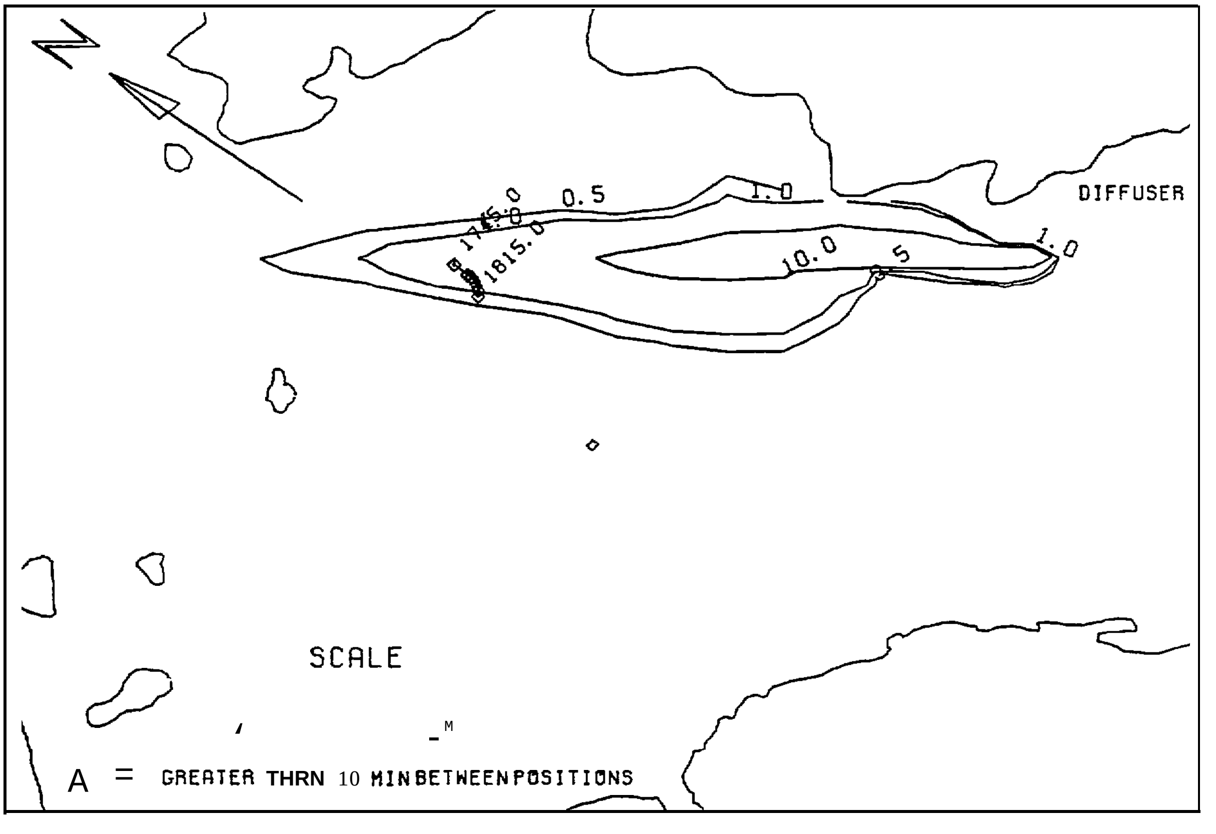


FISH 77, TREATMENT NO. 3, PLUME AT 19:00

Horizontal Movements of Fish Number 77 and Plume Trajectories at Time Intervals During Treatment 3
Figure 3-32 (continued)



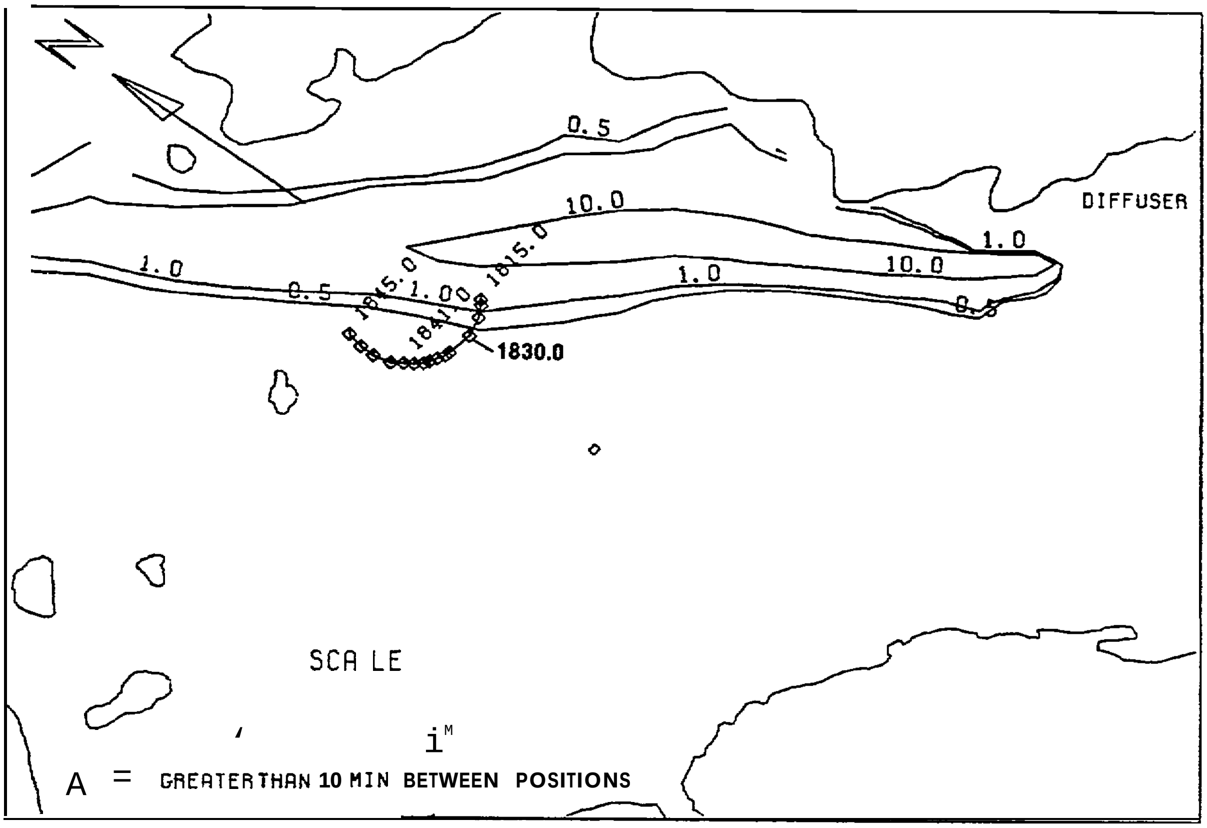
FISH 82, TREATMENT NO. 3, PLUME AT 17:30



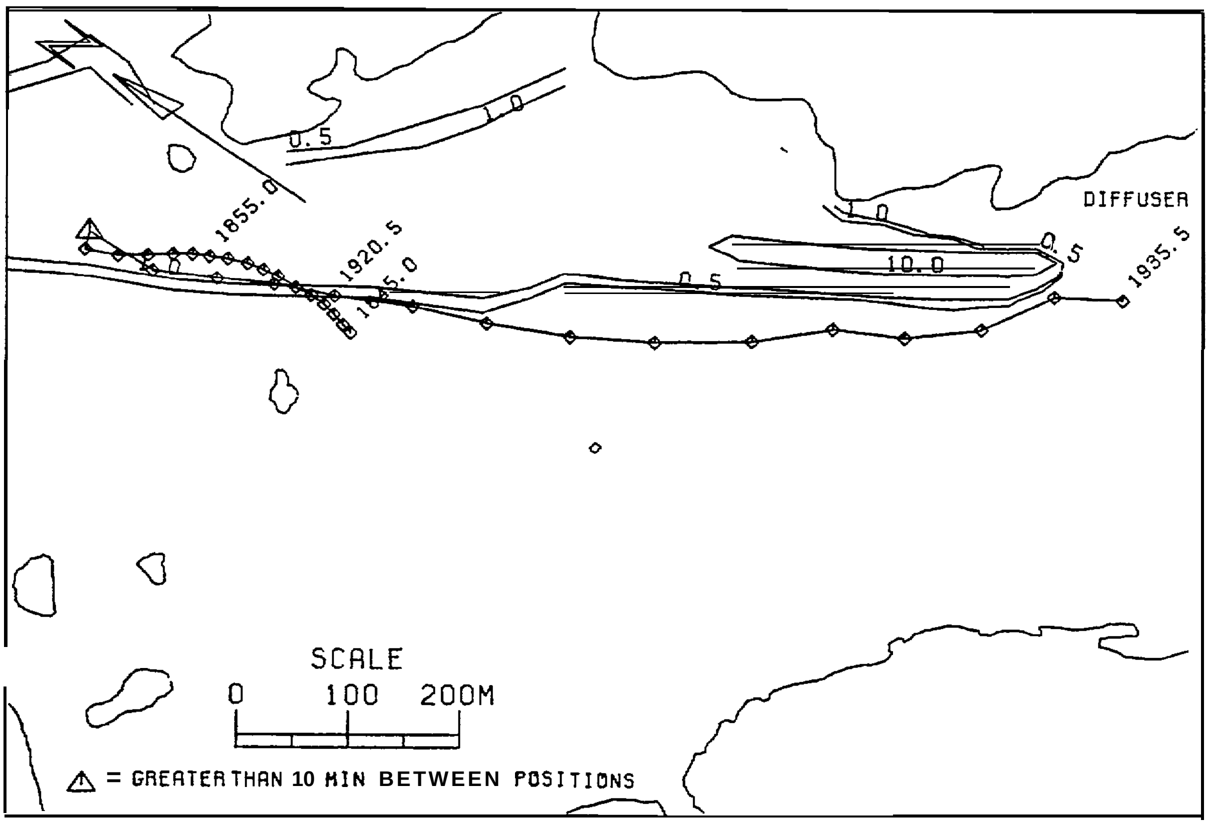
FISH 82, TREATMENT NO. 3, PLUME AT 18:00

Horizontal Movements of Fish Number 82 and Plume Trajectories at Time intervals During Treatment 3

Figure 3-33

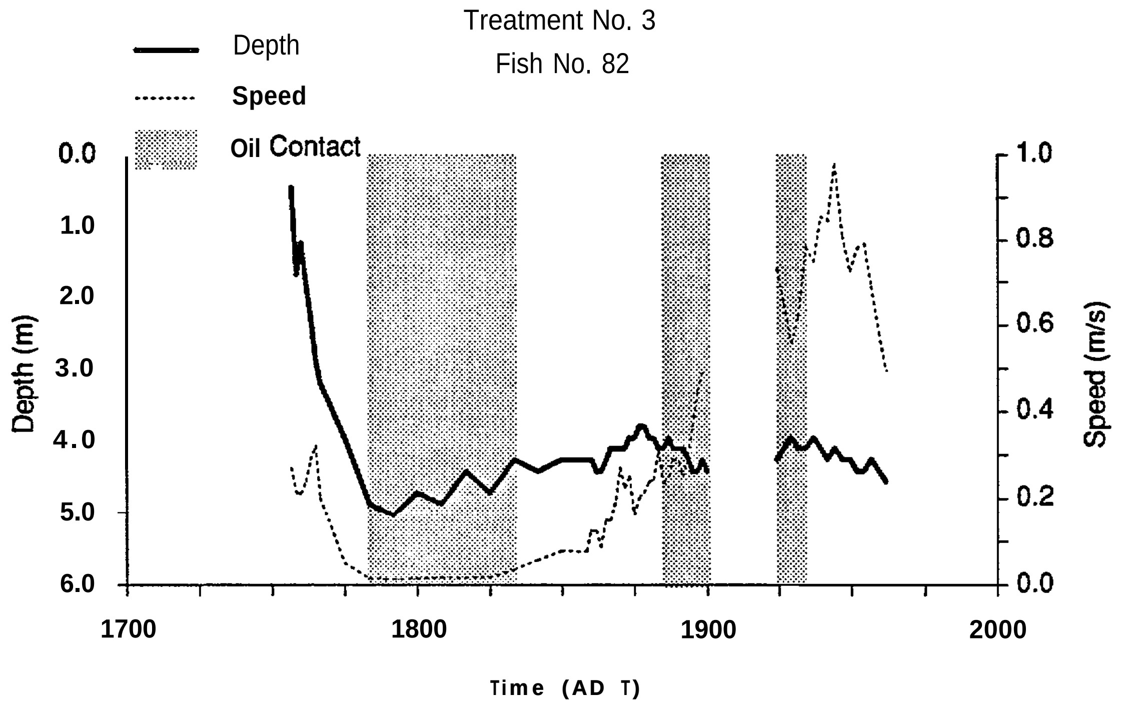


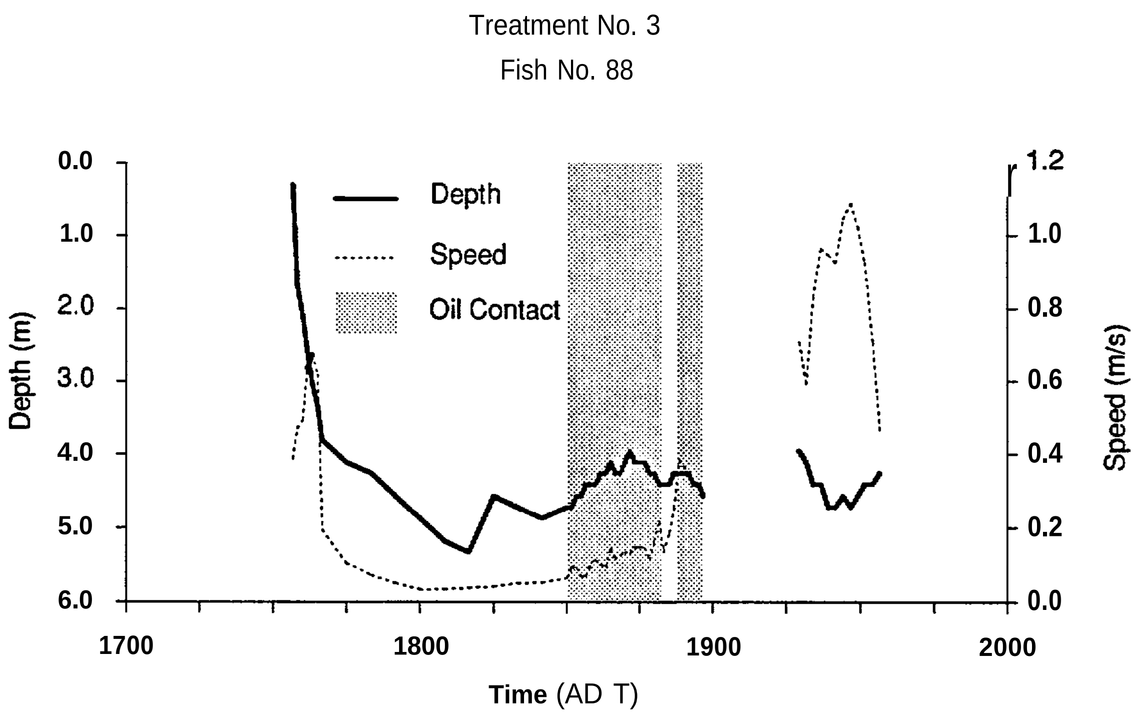
FISH 82, TREATMENT NO. 3, PLUME AT 18:30



FISH 82, TREATMENT NO. 3, PLUME AT 19:00

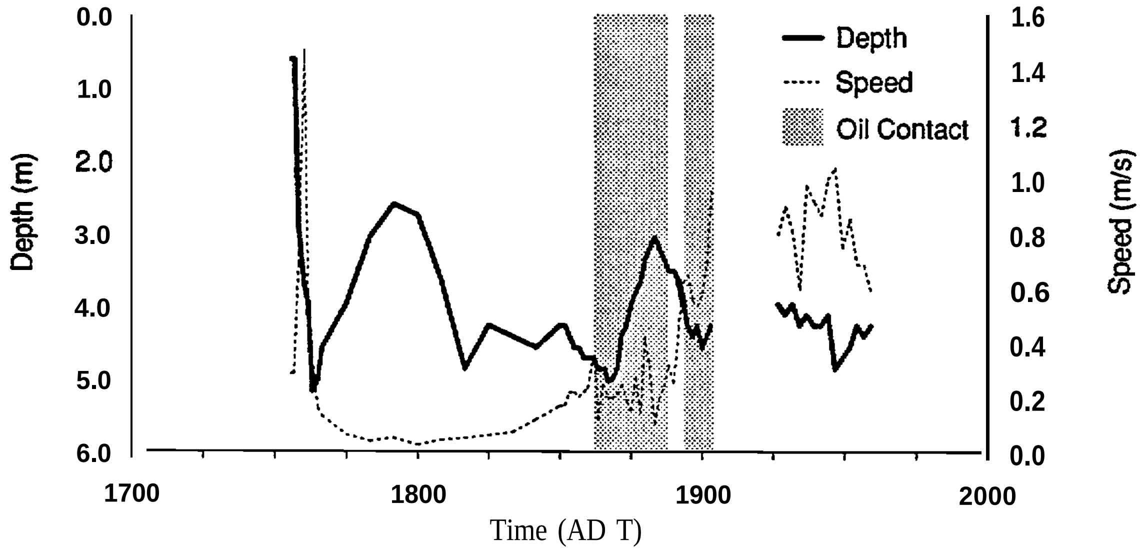
Horizontal Movements of Fish Number 82 and Plume Trajectories at Time Intervals During Treatment 3
Figure 3-33 (continued)



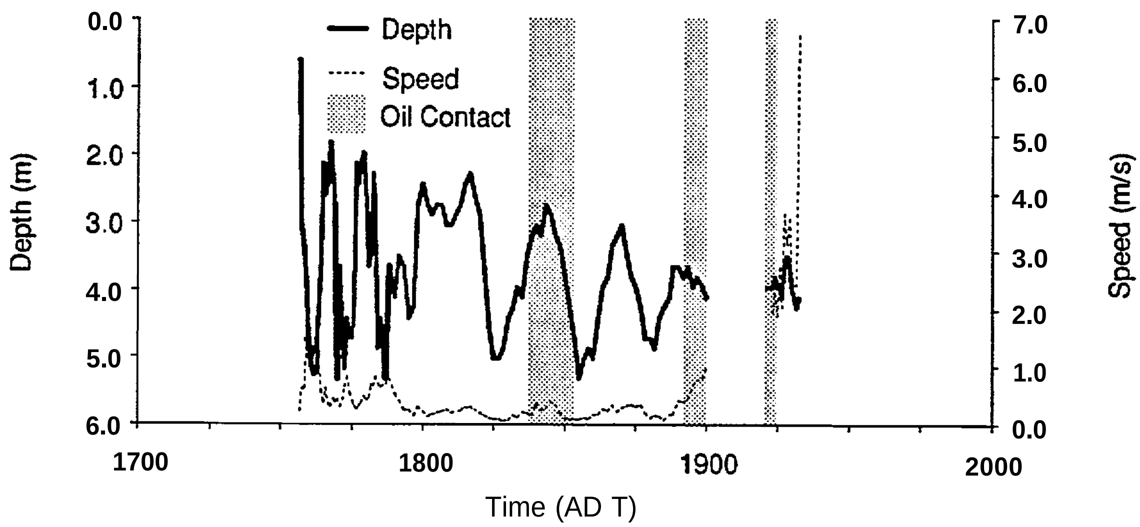


Depth and Ground Speed Versus Time and Time of Oil Contact for Fish Numbers 82 and 88 During Treatment 3
Figure 3-34

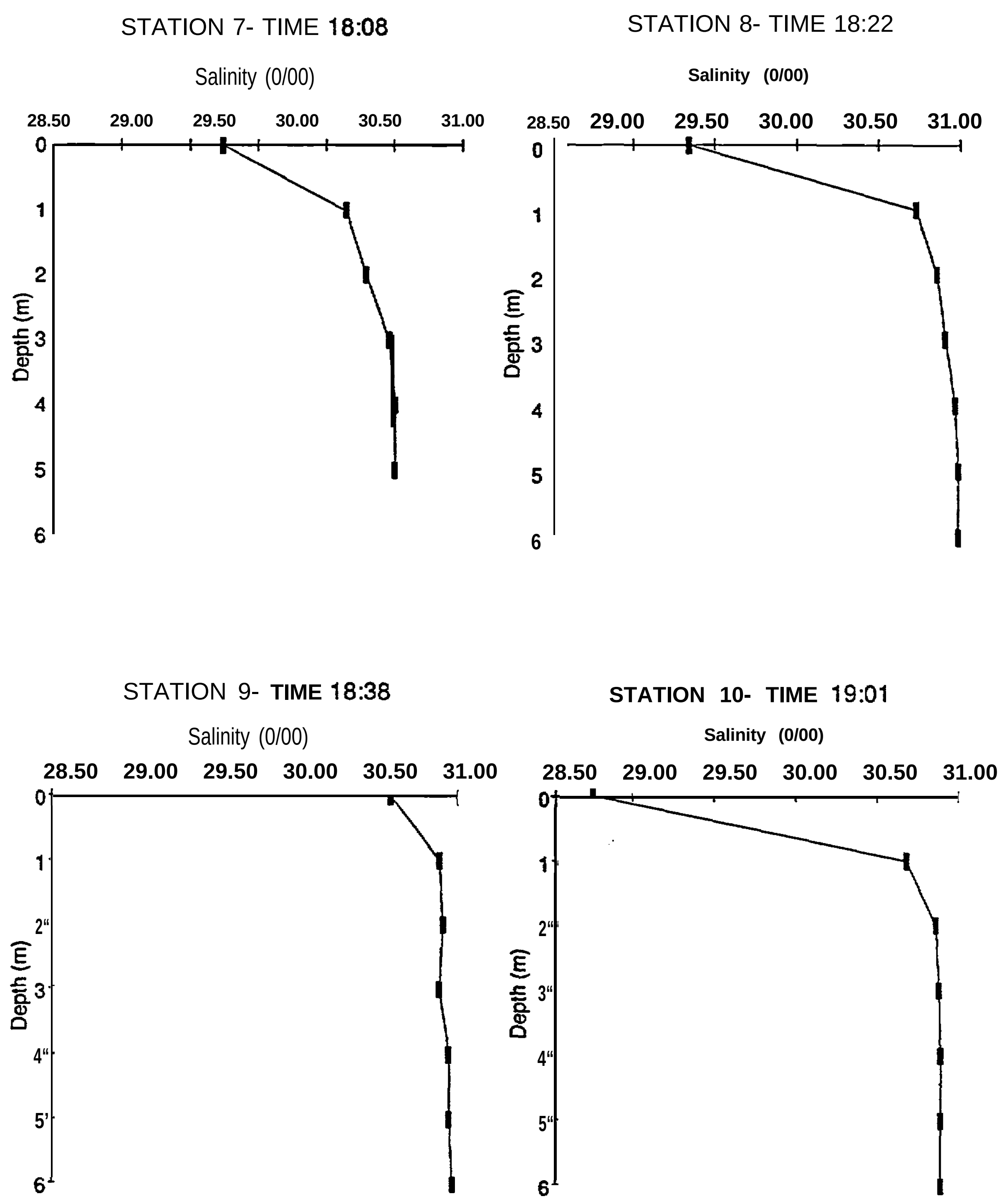
Treatment No. 3
Fish No. 73



Treatment No. 3
Fish No. 83



Depth and Ground Speed Versus Time and Time of Oil Contact for Fish Numbers 73 and 83 During Treatment 3
Figure 3-35



Salinity Profile with Depth for Treatment 3
Figure 3-36

4.0 DISCUSSION

4.1 SALMON MOVEMENT BEHAVIOR IN RESPONSE TO OIL CONTAMINATED WATERS

Differences in movement behavior of salmon during treatment 3 compared to the behavior of salmon during the control experiments indicated that hydrocarbon concentrations ranging 1.0 to 10.0 ppb caused a temporary disruption of the salmon migration to the home stream. Fish returning to the home stream through uncontaminated waters spent less time searching, showed positive rheotactic movements, and swam at the depth of the interface of the steep salinity gradient. Fish exposed to contaminated waters spent significantly more time searching, showed negative rheotactic movements, and swam at a depth well below the interface of the steep salinity gradient. Following this behavior salmon displayed an active migration behavior (positive rheotaxis) and successfully returned toward the home stream by migrating initially through low hydrocarbon concentrations (i.e., approximately 1.0 ppb) along the plume edge and finally through uncontaminated waters outside of the plume. The location of the return route was similar to the return route utilized by fish during the control experiments, indicating the home stream chemical cues, which are used for orientation, were not completely contaminated by the hydrocarbon plume.

The cause for this change in behavior and the resulting delay of the return migration after oil exposure is not clear. Salmon exposed to hydrocarbon concentrations greater than 1.0 ppb are either avoiding contaminated water by searching for an uncontaminated route or are becoming temporarily disoriented until they eventually swim clear of the plume. Understanding the mechanism for this delay is confounded by the timing when fish were exposed to the plume. Salmon encountered the plume during the searching phase of their return; therefore, the response observed may or may not be entirely due to the effects of oil. Horizontal movement patterns and the duration of the return varied during the control experiments, indicating factors other than oil contamination affect movement behavior. Variation in movement behavior during the searching phase may be related to differences in current speed and the depth of low salinity surface waters, which may affect how quickly salmon can detect the home stream cue. Had salmon encountered the plume during the active migration phase when fish were assumed to be homing, the interpretation of results would likely be more clear.

The distinction between avoidance and disorientation requires an identification of specific behavioral characteristics during migration that are indicative of either an avoidance or a disorientation response. Avoidance in this case is defined as detection of unsuitable conditions coupled with continued orientation (i.e., no loss of home stream cue) and disorientation is defined as inability to detect chemical cues necessary for orientation either by sensory impairment or by masking. Based on these definitions, a salmon avoiding the plume would likely display a searching behavior with the extent of the vertical and horizontal search more-or-less limited by the boundaries of the home stream cue. Since movement in or adjacent to the home stream cue is required for orientation, salmon could only avoid the contaminant if an uncontaminated route existed within the boundaries of the home stream cue. If the latter condition exists, then searching movements that take the fish out of the plume should be immediately followed by active migration behavior and a return to the home stream. In contrast, a salmon that became disoriented would display a searching behavior (i.e., vertical and horizontal movements) that would not be limited by the boundaries of the home stream cue because the chemical cue would not be detectable. Based on homing behavior observed in freshwater (Johnsen 1982), a loss of the home cue (i.e., disorientation) would result in negative rheotactic movements until the fish could reestablish the cue. Homing could only be successful if a portion of the home stream cue were uncontaminated and only for those fish that by chance migrated along the uncontaminated route or if the fish fell back and sensory impairment was removed.

The movement behavior observed during treatment 3 suggests that adult pink salmon may become disoriented in the presence of hydrocarbon concentrations ranging 1.0 to 10.0 ppb. All fish showed negative rheotactic movements and headed down bay after or during exposure to the hydrocarbon plume. All but one of these fish continued down bay out of tracking range. This behavior would suggest the fish were unable to detect the home stream cue. Fish that conducted horizontal searches both within and outside of the plume (e.g., fish nos. 82 and 83) did not detect the home stream cue even though the search pattern outside of the plume crossed the eventual return route. This response suggests the chemosensory capabilities may have been impaired. Pearson et al. (1987) found the chemosensory capabilities of coho salmon were temporarily degraded (i.e., a few minutes) when fish were exposed to hydrocarbon concentrations (composed of 97% monoaromatics) of 0.1 to 1.0 ppb for 30 minutes, Exposure to WSF concentrations above 1.0 ppb and for longer periods have not been evaluated, therefore, the lasting effects of chemosensory impairment are unknown. Fish nos. 82 and 83 were exposed to concentrations >5.0 ppb for 3 to 4 minutes and to concentrations ranging 1.0 to 5.0 ppb for up to 41 minutes. The eventual return of these fish and the other fish that headed down bay indicates that the cause for the negative rheotaxis was temporary. These fish presumably headed down bay or passively fell back out of the hydrocarbon plume, became oriented in uncontaminated waters, and returned along the home stream cue. The latter assumption is supported by the behavior of fish no. 77, which successfully homed after negative rheotactic movements resulted in movement outside the plume. After a period of 10 to 15 minutes outside the plume fish no. 77 turned and actively migrated toward the home stream. All the fish that headed out of tracking range down bay returned after 12 to 19 minutes, which is similar to the orientation period exhibited by fish no. 77.

Examples of disruptions of salmon migration due to oil or other water pollution are rare. Weber et al. (1981) reported that adult coho salmon returning to two parallel fish ladders avoided usage of one ladder when contaminated with WSF concentrations reaching 3.2 ppm. Pearson et al. (1987), however, speculates that the result of this study was not an example of avoidance, but rather an indication of disorientation and most likely as a result of chemosensory impairment. Pearson et al. (1987) reanalyzed the data from Weber et al. (1981) and found that the WSF released into the test stream was at levels sufficient to cause chemosensory impairment and that fish returns to the stream were correlated with WSF concentration. Pearson et al. (1987) believe that chemosensory impairment was inhibiting salmon from locating the test stream during the experiments. Saunders and Sprague (1967) reported that Atlantic salmon avoided high levels of zinc and copper pollution in a tributary of the Miramichi River by returning prematurely downstream during their normal spawning migration. Pearson et al. (1987) were also critical of these results because they point out that heavy metals are known to reduce olfactory response in salmonids. Therefore, the downstream movement observed by Saunders and Sprague (1967) is more likely due to the loss of ability to detect the home stream odor. Westerberg (1983a) observed negative rheotactic movements by Atlantic salmon released in a branch of the Lule estuary that was polluted with effluent from a steelworks and coke plant, whereas, salmon released in an unpolluted branch of the same estuary showed a slow but steady migration upstream. The latter may also be an example of disorientation due to chemosensory impairment. Results of these studies suggest that other pollutants, which affect chemosensory detection, may have a similar affect on migrating salmonids as was observed in this study.

4.2 IMPLICATIONS OF STUDY FINDINGS TO OIL SPILL SCENARIOS

Since all salmonids require chemosensory detection for orientation during migration, the effects of oil exposure are likely to be similar for all species. The results of this study suggest that adult salmon will become disoriented when exposed to hydrocarbon concentrations ranging 1.0 to 10.0 ppb. The concentration of hydrocarbons in the water column from accidental oil spills have ranged well above these levels (see review by Pearson et al. 1987). Therefore, it is likely that an oil spill in the path of migrating salmon could cause some disruption of the migration. The magnitude of a potential disruption would depend on the size and persistence of the spill. If the spill contaminated the entire width of the home stream corridor the migration could be blocked as a result of chemosensory impairment and loss of the ability to detect the home stream cue (Pearson et al. 1987). Disorientation and subsequent negative rheotactic behavior would probably cause salmon to hold at some location outside of the contaminated area, but within the home stream cue. Attempts to migrate through the contaminated area would most likely fail until WSF concentrations decrease below the threshold level causing chemosensory impairment. Since aromatic hydrocarbons are responsible for chemosensory degradation (Johnson 1977) and these lower molecular weight hydrocarbons are the first to dissipate from an oil spill (Clark and MacLeod 1977), the duration of the disruption may range from a few days to several weeks. Payne et al. (1984) investigated oil weathering in marine waters and found the low molecular weight aromatics were removed after 6 to 12 days by a combination of evaporation and advective processes. However, if oil is more completely dispersed into the water column by dissolution its rate of removal can take longer (Jim Payne, personal communication). For example, an assessment of several hypothetical oil spill scenarios in Bristol Bay, assuming maximum effect conditions, estimated the maximum duration that WSF concentrations >1.0 ppb would persist is 36 days (Pola et al. 1985).

A simulation of the effects of a potential oil spill scenario on migrating adult sockeye salmon in Bristol Bay was conducted by Bax (1987). Impacts on the population due to tainting and/or mortality were based on exposure thresholds derived from the literature and for two conditions: either avoidance or non-avoidance of the spill. Given these assumptions the model predicted maximum mortality and tainting impacts ranging 1% to 5% and 1 % to 2% of the total returning population, respectively. This scenario, however, may not be realistic because it does not include the possibility for fish to become disoriented, which could have a different impact on the population. Disorientation and subsequent negative rheotactic movements may not result in fish exposure to levels sufficient to cause mortality or tainting, but may result in other impacts caused by migration delays. Thus, Bax (1987) estimates of impacts due to mortality and tainting may be too high. The question of impacts to the population due to migration delays or straying was not addressed and may be a more significant consequence of an oil spill.

Adult sockeye returning to Bristol Bay maybe highly vulnerable to migration disruptions due to their specific migration routes and narrow return timing. The distribution of salmon stocks offshore are mixed when the fish enter the bay and become more segregated as the fish approach their natal river (Bax 1987 and Strat y 1975). Return timing is very consistent from year-to-year with 80% of the run passing the f ishery over a 13 day period (Burgner 1980). This concentration of the population in a relatively small area during a short time period increases the Vulnerability for impacting a significant portion of the population or an entire stock, An oil spill along the migratory route that delays a specific stock for one or two weeks could have a significant effect on time of spawning and subsequent survival of offspring. Time of spawning for sockeye stocks are synchronized with the specific temperature regime of the home stream (Miller and Brannon 1982). In Bristol Bay spawning within a particular river or stream is restricted to a period of less than two weeks (based on spawner survey data from Demory et al. 1964). This narrow window for spawning is dictated by embryo incubation requirements and the timing of fry emergence necessary to correspond with food availability of the nursery system. Late emergence may result in a size disadvantage and less time for growth to produce optimal smelt size the following spring (Miller and Brannon 1982). A delay of the migration for two weeks prior to entry in the fishery may also result in direct economic losses due to maturation and a reduction in food quality. Sockeye salmon taken during the end of the run are of lower value to the fishery than fish taken during the peak (Don Rogers, Fish. Res. Inst., Univ. of Wash., personal communication).

An oil spill in an estuary of Bristol Bay would potentially have the greatest impact on a salmon population. Salmon migration into the home stream may be reduced or completely blocked as a result of disorientation and the subsequent retrograde movement out of the contaminated area. Only those fish that by chance migrate through areas uncontaminated by the spill may successfully return to the home stream. Fish that are unsuccessful may hold until the spill dissipates or they may stray to other neighboring streams where they could eventually spawn. Saunders and Sprague (1967) reported that 62% of the Atlantic salmon, which returned downstream as a result of heavy metal pollution, were never seen again and 31 % reascended the river after pollutant levels declined. Significant numbers of adult coho and chinook salmon returning to the Toutle River following the eruption of Mount St. Helens, strayed to several neighboring rivers up to 121 km away (Martin et al. 1984). Survival in non-natal streams would likely be low due to competition with natal stocks and incompatibility with local environmental conditions.

4.3 CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this study are:

° Migrating adult pink salmon do not appear to avoid aromatic hydrocarbon concentrations above the chemosensory detection threshold,

- Salmon do not appear to avoid oil contaminated waters with hydrocarbon concentrations ranging 1 to 10 ppb, but appear to become temporarily disoriented,

- Salmon behavior during disorientation was characterized by an extended period of searching and negative rheotactic movement, and

- Disorientation caused a temporary disruption of the return migration but did not prevent the eventual return to the home stream.

These findings suggest that pink salmon encountering an oil spill along their migratory route may not be exposed to levels causing tainting or mortality. Instead disoriention to low hydrocarbon concentrations would cause the fish to retreat back along the migratory route until orientation was reestablished. Continued attempts to migrate through the spill would probably fail as long as the migratory route remained contaminated. This may result in a delay in migration that could have a significant effect on the time of spawning and subsequent survival of offspring or cause straying to other streams where the probability of survival would be lower.

The conclusions of this study should be viewed with caution because they are based on a small amount of information. Further research is necessary: to verify the consistency of the avoidance/disorientation response of salmon to low hydrocarbon concentrations, to determine behavior and fate of salmon encountering a spill that contaminates either the entire width or a portion of the migratory route, and to investigate olfactory responses at exposure levels (concentration and duration) similar to those observed in this study. Repeating this field investigation, with some modification, would be required to address the first two research needs. Verification of the avoidance/disorientation response would be more clearly identified if the fish encounter the plume during the active migration phase rather than during the search phase of their return. This may be accomplished by releasing the fish from a point further downbay and by coordinating the timing of plume release to intercept salmon as they move up bay. A greater distance between the diffuser and fish release site would enable fish to become oriented and actively migrating prior to encountering the plume. Movement behavior in response to oil exposure could be separated from movements observed during the searching phase. A greater distance between the diffuser and fish release site would also enable testing of the effects of partial and complete contamination of the home cue. This could be accomplished by adding another diffuser, which when combined with the original diffuser would contaminate the entire width of the bay.

In addition to fish tracking during experiments, a continuous monitoring system should be operated after the experiments to record timing of fish returns for fish that may have been blocked by the plume and eventually return at a later date. The latter information could be used to access the fate of fish exposed to partial or complete contamination of the home cue. Research needs concerning olfactory response to hydrocarbon concentrations ranging up to 10 ppb would require a laboratory investigation similar to Pearson et al. (1987).

5.0 LITERATURE CITED

Bax, N.J. 1987. Effects of a tanker accident and oil blowout in Bristol Bay, Alaska on returning adult sockeye salmon (Oncorkynchus nerka), a simulation study. Marine Environmental Research 22177-130.

Bertmar, G. and R. Toft. 1969. Sensory mechanism of homing in salmonid fish. 1. Introductory experiments on the olfactory sense in grilse of baltic salmon (Salmo salar). Behavior 35:235-241.

Burgner, R.L. 1980. Some features of ocean migrations and timing of Pacific salmon. Pages 153-164 In McNeill, W.J. & Himsworth, D.C., editors. Salmonid ecosystems of the North Pacific. Oregon State Univ. Press, Corvallis, Oregon.

Clark, R. C. Jr. and W. D. MacLeod. 1977. Inputs, transport mechanisms, and observed concentrations of petroleum in the marine environment. Pages 91-224 In D. C. Malins, editor. Effects of petroleum on Arctic and Subarctic marine environments and organisms, volume 1, nature and fate of petroleum. Academic Press, New York.

Dames & Moore, 1985. The two-dimensional hydrodynamic model TIDAL2 and water quality model WQUAL2. User's Manual and Program Description, Dames & Moore Report. Los Angeles.

Demory, R., R. Orrell, and D. Heinle. 1964. Spawning ground catalog of Kvichak River, Bristol Bay. U.S. Fish and Wildlife Service. Special Scientific Report, Fish No. 488.

Doving, K. B., H. Westerberg and P.B. Johnsen. 1985. Role of olfaction in the behavioral and neuronal responses of Atlantic Salmon (Salmo salar) to hydrographic stratification. Can. J. Fish. Aquat. Sci. 42:1658-1667.

Fischer, H. B., E. J. List, R. C. Y. Koh, J. Imberger, and N. H. Brooks. 1979. Mixing in inland and coastal waters. Academic Press, San Francisco

Johnsen, P.B. 1982. A behavioral control model for homestream selection in salmonids. Pages 266-273 In E.L. Brannon and E.O. Sale, editors. Proceedings of the Salmon and Trout Migratory Behavior Symposium, School of Fisheries, University of Washington, Seattle, WA.

Johnsen, P.B. and A.D. Hasler. 1980, The use of chemical cues in the upstream migration of coho salmon, Oncorhynchus kisutch Walbaum. J. Fish. Biol. 17:67-73.

Johnson, F.G. 1977. Sublethal biological effects of petroleum hydrocarbon exposure in fish. Pages 271-318 In D.C. Malins, editors. Effects of Petroleum on Arctic and Subarctic Marine Environments and Organisms. Academic Press, New York.

Leendertse, J. J. 1970. A water-quality simulation model for well mixed estuaries and coastal seas: vol. 1, principles of computation. The Rand Corporation RM-6230-RC.

Martin, D. J., L. J. Wasserman, R. P. Jones, and E. O. Sale. 1984. Effects of Mount St. Helens eruption on salmon populations and habitat in the Toutle River. Univ. of Wash., Fisheries Research Institute, Final Technical Completion Report, U.S. Dept. of the Interior, Bureau of Reclamation, Grant No. 14-34-0001-1418.130 PP.

McAulif fe, C.D. 1969. Determination of dissolved hydrocarbons in subsurface brines. Chem. Geol. 4:225-233.

___. 1971. GC determination of solutes by multiple phase equilibration. Chem. Technol. 1:46-51.

_. 1980. Multiple gas-phase equilibrium method and its application to environmental studies. Pages 193-218 In L. Petrakis and F.T. Weiss, editors, Advances in Chemistry Series, No. 185. American Chemical Society.

Miller, R. J. and E. L. Brannon. 1982. The origin and development of life history patterns in Pacific salmonids. Pages 296-309 In E. L. Brannon and E. O. Sale, editors. Proceedings of the Salmon And Trout Migration Behavior Symposium, School Of Fisheries, Univ. of Wash., Seattle, WA.

Moles, A., S.E. Rice, and S. Andrews. 1985. Continuous-flow devices for exposing marine organisms to the water-soluble fraction of crude oil and its components. Can. Tech. Rep. Fish Aquatic. Sci. 1368:53-61.

Muellenhoff, W. P, A. M.Soldate, D. J. Baumgartner, M. D. Schuldt, L. R. Davis and W. E. Frick. 1985. Initial mixing characteristics of municipal ocean discharges: Volume 1 - Procedures and Applications. Environmental Research Laboratory, U.S. EPA, Narragansett, RI, EPA/600/3-85/073a.

Nakatani, R. E., E.O. Sale, A.E. Nevissi, R.P. Whitman, B.P. Snyder and S.P. Kaluzny. 1985. Effect of Prudhoe Bay crude oil on the homing of Coho Salmon in marine waters. American Petroleum Institute, Publication No. 4411, September 1985. 55 pp.

National Research Council. 1985. Oil in the sea, inputs, fates, and effects. National Academy Press.

Payne. J. R., G. D. McNabb, Jr., and J. R. Clayton, Jr.. 1988. Sampling and analyses of aliphatic/aromatic cocktail solutions, water-soluble extracts, and selected environmental samples from the Jakolof Bay oil spill in support of the Dames & Moore salmon tracking study. U.S. Dept. of Commer., NOAA, Data Report for Contract No. 85-ABC-00148. 29PP.

Payne, J. R., B.E. Kirstein, G.D. McNabb, Jr., J.L. Lambach, R. Redding, R.E. Jordan, W. Horn. deOliveira, G.S. Smith, D.M. Baxter and R. Gaegel. 1984. Multivariate analysis of petroleum weathering in the marine environment - sub-arctic. U.S. Dept. of Commer, NOAA, OCSEAP Final Rep. 21. 633 pp.

Pearson, W. H., D.L. Woodruff, and P.B. Johnson. 1987. Effects of petroleum contaminated waterways on spawning migration of Pacific salmon, Phase I laboratory studies. Draft Final Report for NOAA, Ocean Assessment Division, Alaska Office, Anchorage, Alaska. 63 pp.

Pola, N. B., R. K. Miyahara, and A. F. Gallagher, Jr. 1986, Spatial and temporal extent of hydrocarbon contamination in marine species of Bristol Bay. U.S. Dept. of Commer., NOAA, OCSEAP Final Rep. 36 Part 2.663-710.

Saunders, R.L. and J.B. Sprague. 1967. Effects of copper-zinc mining pollution on a spawning migration of Atlantic salmon. Water Res. 1:419-432.

Stoker, J. J. 1957. Water waves. Interscience Publishers, New York.

Straty, R.R. 1975. Migratory routes of adult sockeye salmon, Oncorhynchus nerka, in the eastern Bering Sea and Bristol Bay. NOAA Tech. Rep. NMFS SSRF-690, 32 pp.

Weber, D. D., D.J. Maynard, W.D. Gronlund and V. Konchin. 1981. Avoidance reactions of migrating adult salmon to petroleum hydrocarbons. Can. J. Fish. Aquat. Sci., 38, 779-781.

Westerberg, I-I. 1984. The orientation of fish and the vertical stratification of fine and microstructure scales. Pages 179-204, In J.D. Cleave, W.H. Neill, J.J. Dodson and G.P. Arnold, editors. Mechanisms of Migration in Fishes. Plenum Publ. Corp. New York.

_. 1983a. Ultrasonic tracking of Atlantic salmon (Salmo sal or L.) - I. Movements in coastal regions. Swedish Inst. of Freshw. Res., Rept. 60, 81-99.

1983b. Ultrasonic tracking of Atlantic salmon (Salmo sal or L.) - II. Swimming depth and 'temperature stratification. Swedish Inst. of Freshw. Res., Rept. 60, 102-117.

APPENDIX A

APPENDIX A

DETECTION LIMITS OF KASITSNA BAY COCKTAIL SAMPLES

KASITSNA BAY COCKTAIL SAMPLES

DILUTION FACTOR	NO DILUTION	0.20*	0.02	0.01
HYDROCARBON:				
Methane	0,15	3.60	4.34	2.08
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.Il.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	4495.01	468.46	31.68	8.15
n-Pentane	1644.32	165.04	12.70	2,62
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	846.07	99.94	7.47	1.85
3-Methylpentane	60.27	4.37	2s45	N.D.
n-Hexane	33.98	2.09	0.20	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	45675.24	6841.48	516.92	229.41
Cyclohexane	1756.14	219.96	17.93	N.D."
n-Heptane	189.75	16.73	1,42	0.75
Methylcyclohexane	496.20	30.48	2.69	1.25
Toluene	15416.43	2452.63	193.50	79.00
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	2049.95	334.33	25.15	10.15
m-, p-Xylene	2684.56	456.74	34,72	13.97
o-Xylene	365.29	69.97	5.09	N.D.
Isopropylbenzene	496.70	88.59	6.79	3.08
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	75210.06	11254.41	863.05	352.31
Total w/o C1-C4 '	75209.91	11250.81	858.71	350.23

$$^{*}\frac{\text{Original volume}}{\text{Diluted volume}}$$

KASITSNA BAY COCKTAIL SAMPLES

DILUTION FACTOR	.005	.0025	.0005	.00005
HYDROCARBON:				
Methane	2.14	2.98	3.00	4.21
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	2.61	N.D.	N.D.	N.D.
n-Pentane	0.87	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	0.65	0.10	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	86.39	41.10	3.54	0.55 .
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N:D:	N.D.
Methylcyclohexane	0.73	N.D.	0.09	N.D.
Toluene	36.23	22.79	2.34	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D,	N.D.	N.D.	N.D.
Ethylbenzene	4.11	2.29	N.D.	N.D.
m-, p-Xylene	5.72	4.44	N.D.	N.D.
o-Xylene	O*99	N.D.	N.D.	N.D.
Isopropylbenzene	1.52	0.65	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
	-------	------	*------	-------
Total Hydrocarbons	141.96	74.35	8.97	4.76
Total w/o C1-C4	139.82	71.37	5.97	0,55

APPENDIX B

APPENDIX B

MEASUREMENT OF HYDROCARBONS BY SOLVENT EXTRACTION AND GC ANALYSIS

Hydrocarbon Measurement by Solvent Extraction and GC Analysis

To 20 L of water sample in the carboy container, 500 ml of methylene chloride was added and the mixture was stirred for five minutes using a hand-held electric stirring motor. Then the sample was left for about 15 min to allow separation of the organic phase (bottom layer) from the aqueous phase. The organic phase was syphoned to a 2-L separator funnel and the extraction was repeated twice, with 250 ml CH_2Cl_2 to ensure the complete recovery of hydrocarbons from water. The extracts were combined and the separator funnel was allowed to stand for one hour to complete the separation of the residual water from the solvent. The solvent was transferred to a 1-L round-bottom distillation flask, and the flask was equipped with a Snyder column. The flask was kept in a warm-water bath under a fume hood and most of the methylene chloride was distilled away. The residue was transferred to a small glass vial and the remaining solvent was purged with nitrogen. The residue was transferred to a GC vial and the volume was adjusted to 1 ml. Two microliters were injected automatically in the GC with a capillary column and flame ionization detector.

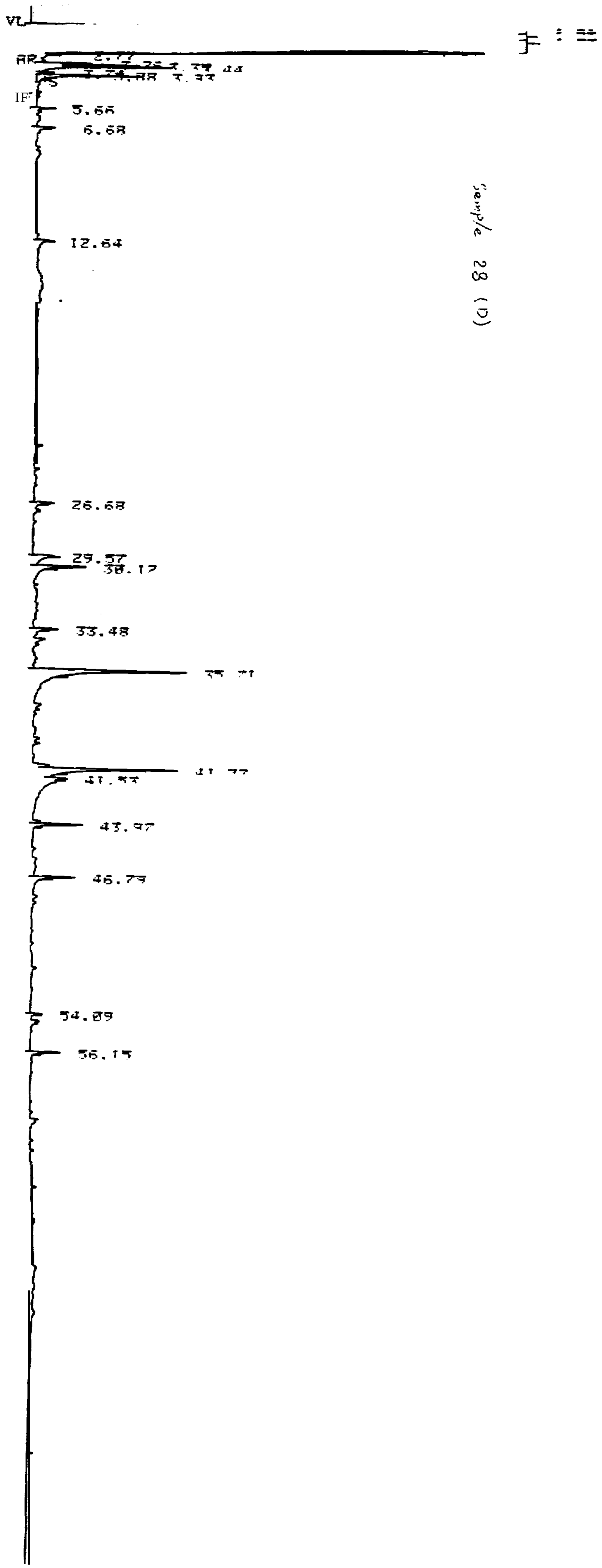
It should be noted that the solvent extraction for GC analysis was neither planned nor proposed for this study. It was undertaken only as an emergency measure to evaluate the effects of a fuel oil spill from a tug and barge operation in the study area. It should also be mentioned that the solvent extraction procedure is designed for measurement of nonvolatile hydrocarbons of WSF such as heavy paraffins and di- and tri-ring aromatic hydrocarbons. The volatile hydrocarbons of the WSF are volatilized and lost from the sample at different rates during extraction, distillation, and purging with nitrogen. Therefore, it is difficult to quantify these losses and apply the necessary correction factors. In addition, the retention time of the solvent CH_2Cl_2 is longer than the retention times of the lighter components of the cocktail; consequently, these components were masked by the CH_2Cl_2 peak. It was possible to use a somewhat lighter solvent with shorter retention time, such as CS_2, to identify qualitatively a few more components of the cocktail. However, because of the health hazards of CS_2 and the inadequacy of the laboratory facility for using hazardous solvents, CS_2 was not used.

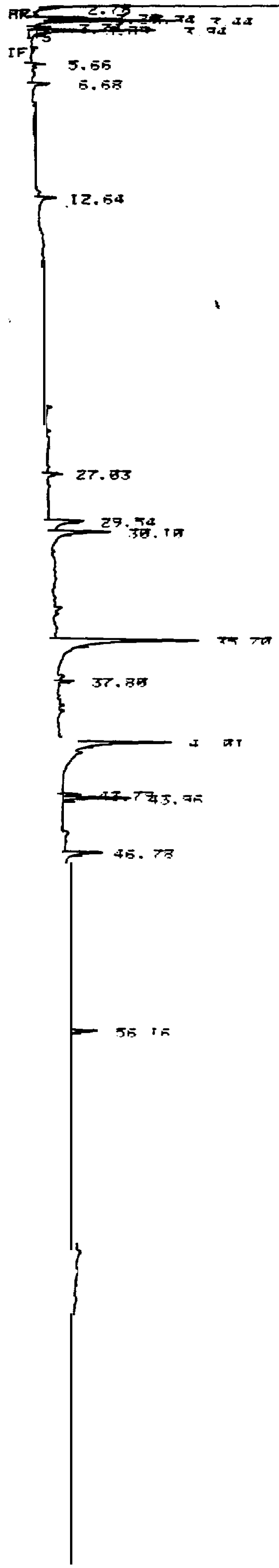
Appendix Table B-1. List of samples taken in 20-liter glass bottles for extraction and analysis by GC.

Sample No.	Description
100	2 m deep at the diffuser site; 1:00 pm, 7/18/88
101	2 m deep at the diffuser site; 1:00 pm, 7/18/88
102	Under the surface at the barge loading site; 3:00 pm, 7/18/88
103	Under the surface at the barge loading site; 3:00 pm, 7/18/88
104	One liter CH_2Cl2 -> 1 ml for blank measurement
105	3 m deep at the diffuser site; 8:05 pm, 7/19/88
106	3 m deep at the diffusre site; 900 pm, 7/19/88
107	Time O, -25 m station 4 m depth, 7/20/88. Pump started at 930 pm.
108	Time O, -25 m station 1 m depth, 7/20/88.
109	Time + 25 min +25 m station 4 m depth, 7/20/88
110	Time + 25 min +25 m station 1 m depth, 7/20/88
111	Time + 45 min + 100 m station 4 m depth, 7/20/88
112	Time +45 min + 100 m station 2 m depth, 7/20/88
113	Time +65 min -25 m station 4 m depth, 7/20/88
114	Time +65 min -25 m station 1 m depth, 7/20/88
115	Time + 85 min + 100 m station, 4 m depth, 7/20/88
116	Time +85 min + 100 m station, 2 m depth, 7/20/88
117	Time + 105 min + 300 m station, 4 m depth, 7/20/88
118	Time + 105 min + 300 m station, 2 m depth, 7/20/88
119	Lateral + 100 m station, 4 m depth, 7/20/88
120	Lateral + 100 m station, 2 m depth, 7/20/88
121	Water sample at the mouth of Jakolof Creek, 1227 pm, 7/21/88 ebb-low tide 0.3 m below surface
122	-25 m, 25 min before start of pump, 4 m depth, 7/23/88 control[a]
123	+ 100 m, 25 min after start of pump, 4 m depth, 7/23/88 control[a]
124	Procedure efficiency
125A	20 rein, -25 station, 4 m depth, 7/24/88, control
126B	40 rein, + 100 station, 4 m depth, 7/24/88, control
127C	110 rein, - 25 station, 4 m depth, 7/25/88, release
128D	130 rein, + 100 station, 4 m depth, 7/15/88, release

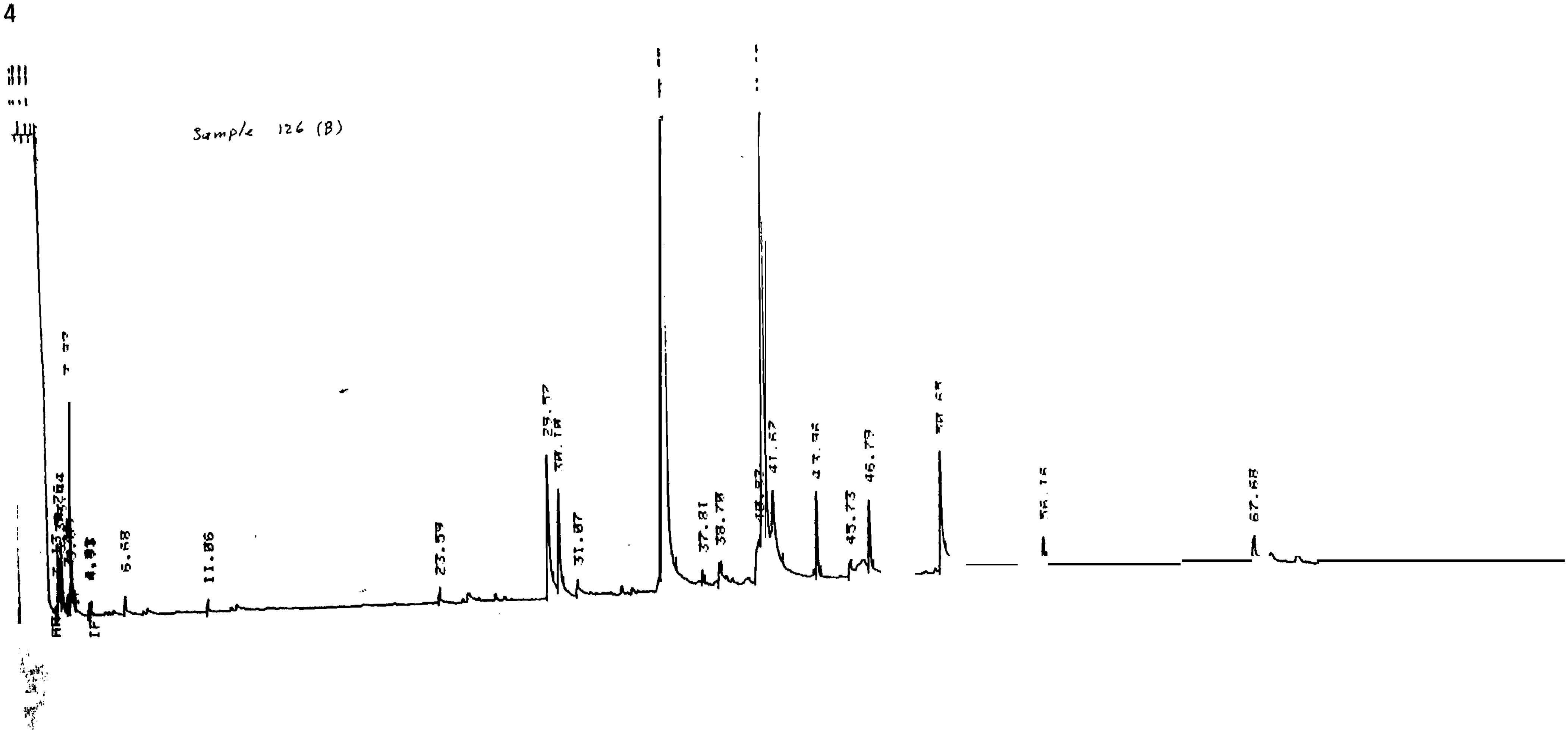
[a] Pump started 1:00 pm.

\bruce\eno\jobs\06797\tb_1


VL
AR
IF
5.66
6.68
12.64
26.68
29.57
30.17
33.48
43.97
46.79
54.09
56.15
Sample 28 (D)

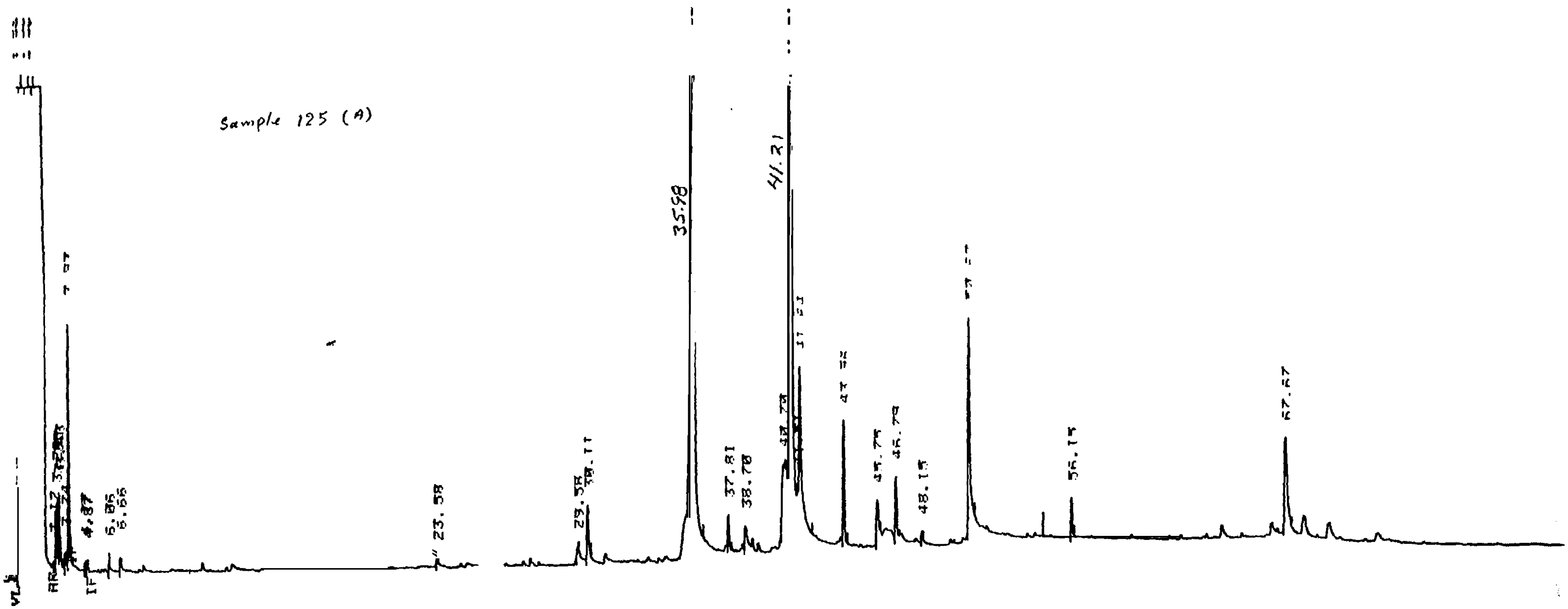


Sample 127 (c)


4
Sample 126 (B)
6.68
11.06
23.59
31.87
37.81
38.78
45.73
46.79
67.68

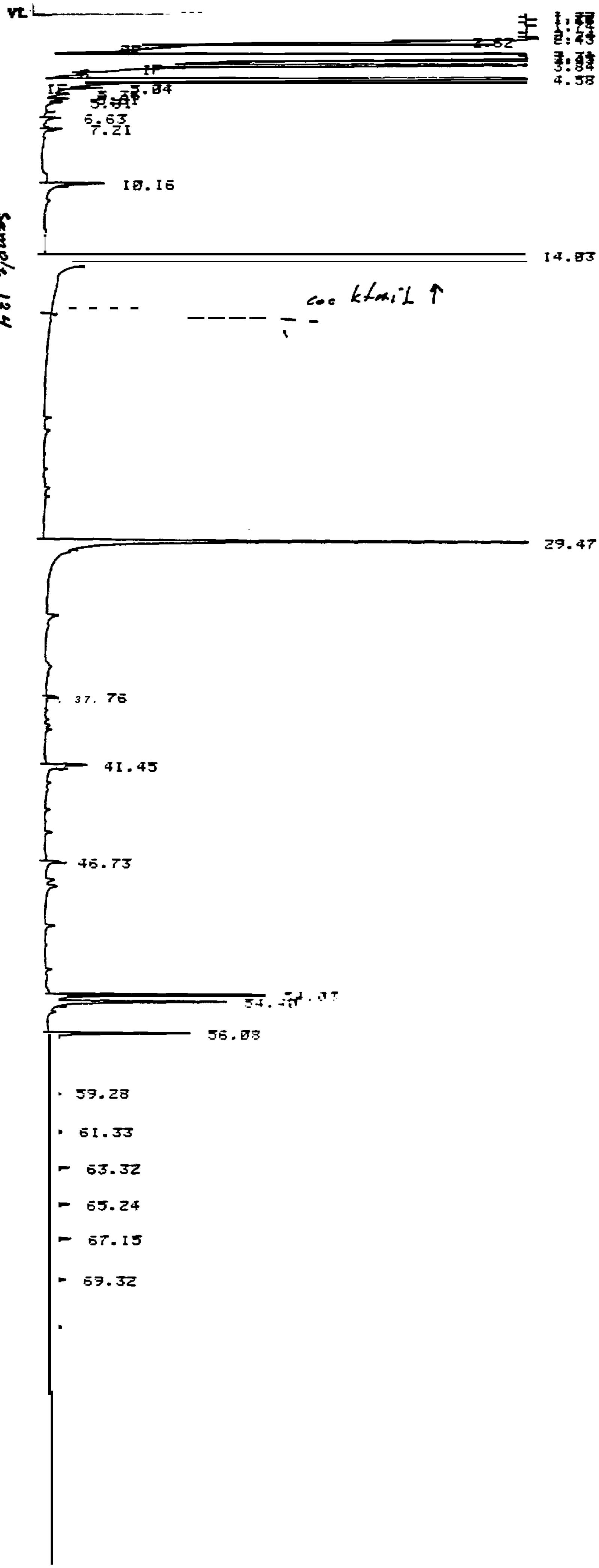
91

92


Sample 125 (A)
4.87
6.06
6.66
23.58
29.58
30.11
35.98
37.81
38.70
41.21
48.15
56.15
67.67

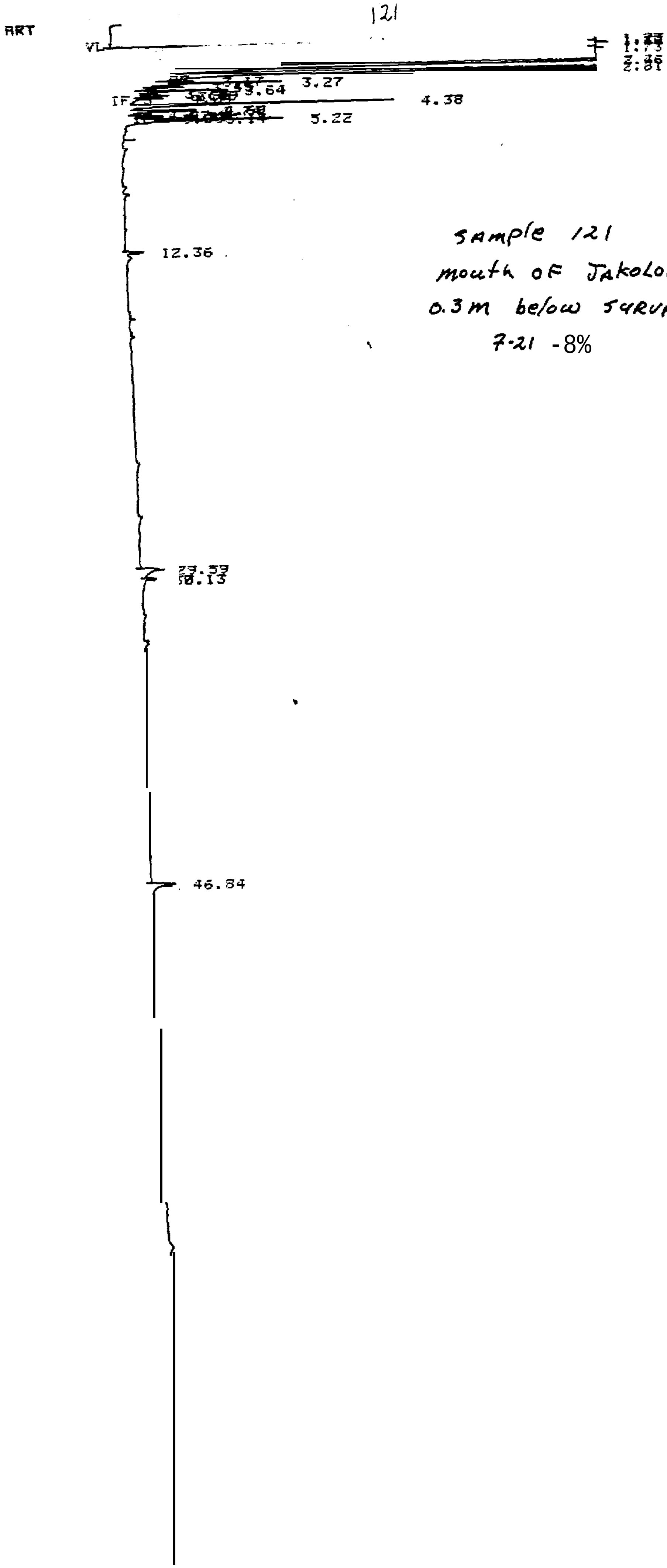
35

Sample 124
extrm. kit-Test, 20 µl cocktail/20 l seawater



15

121

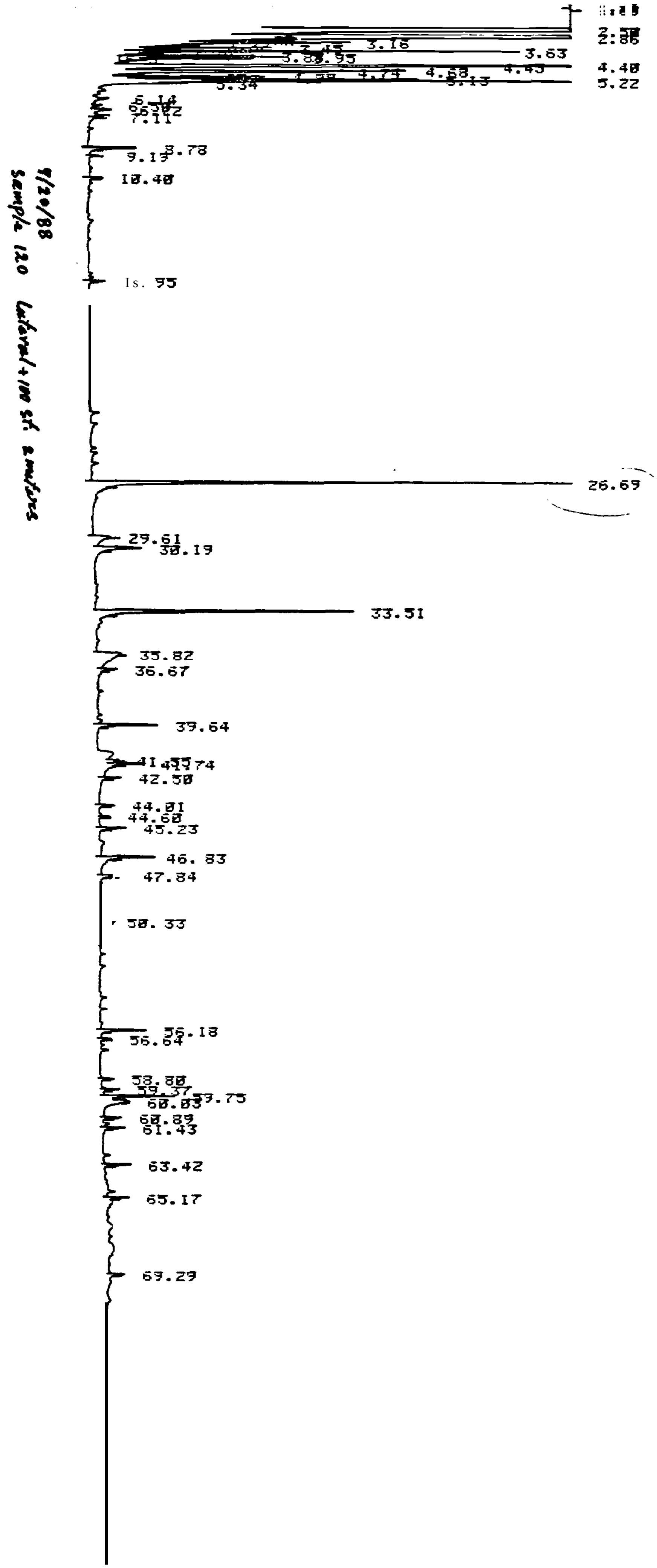


sample 121
mouth of Jakolof
0.3m below surface
7-21 -8%

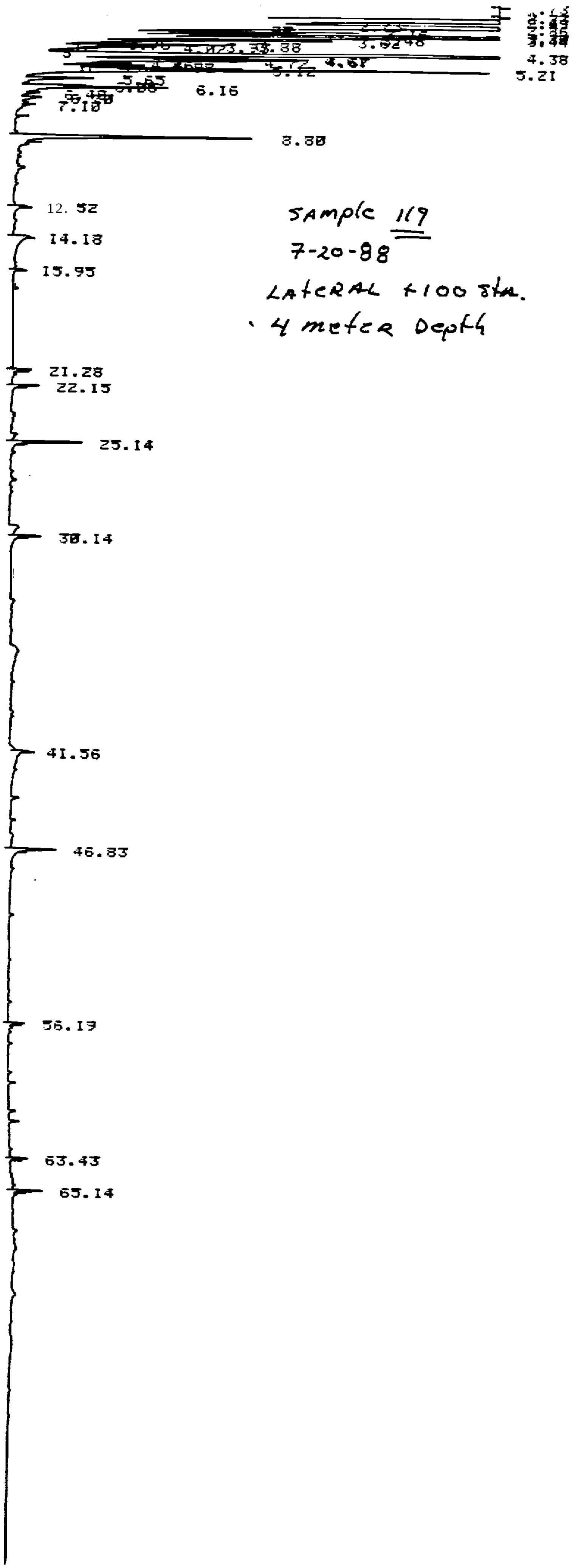
172

173

37

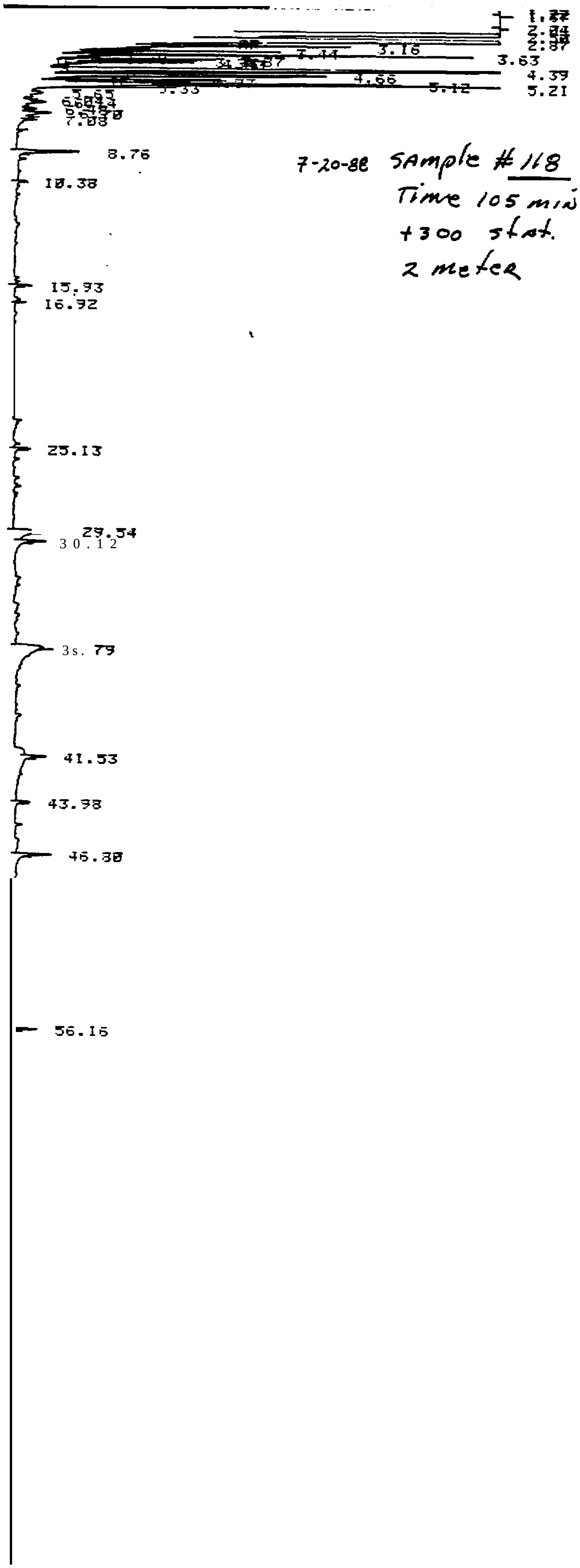

9/20/88
Sample 120 Lateral + 100 st. emulsions
2.86
3.16
3.63
4.40
4.43
4.68
4.74
5.13
5.22
5.34
6.14
7.11
8.78
9.19
10.40
26.69
29.61
30.19
33.51
35.82
36.67
39.64
41.74
42.50
44.01
44.60
45.23
46.83
47.84
50.33
56.18
56.64
58.80
59.37
59.75
60.03
60.89
61.43
63.42
65.17
69.29

169



sample 119
7-20-88
Lateral +100 sta.
4 meter Depth

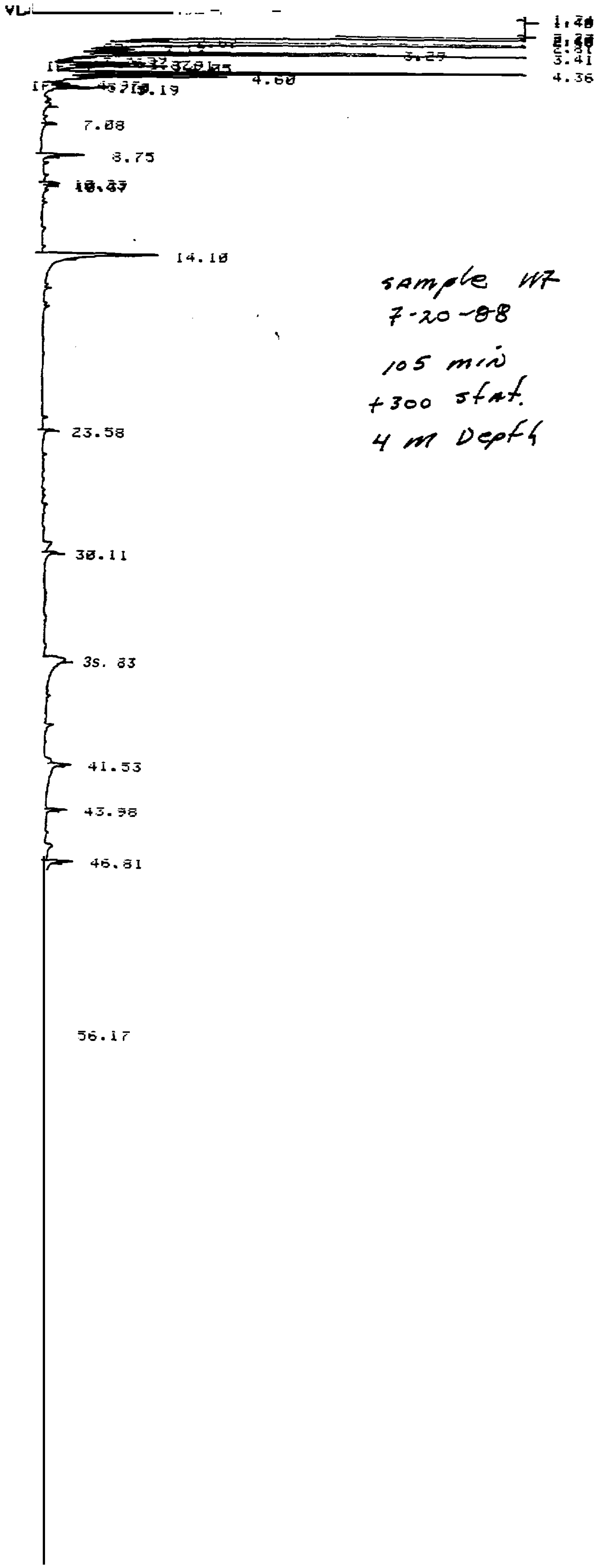
27



7-20-88 Sample # 118
Time 105 min
+300 stat.
2 meter

162

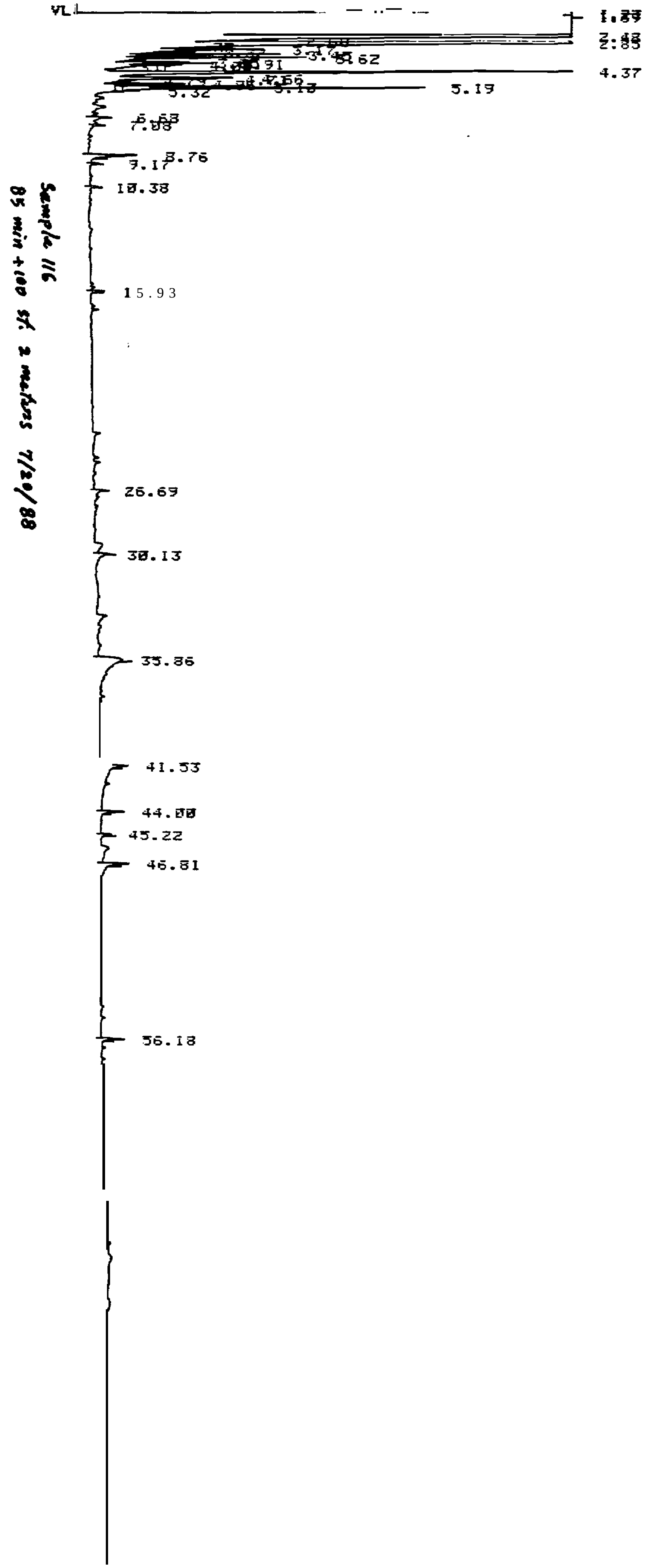
163

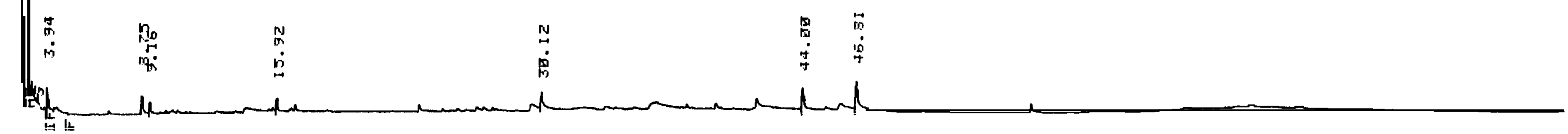


sample W7
7-20-88
105 min
+300 stat.
4 m Depth

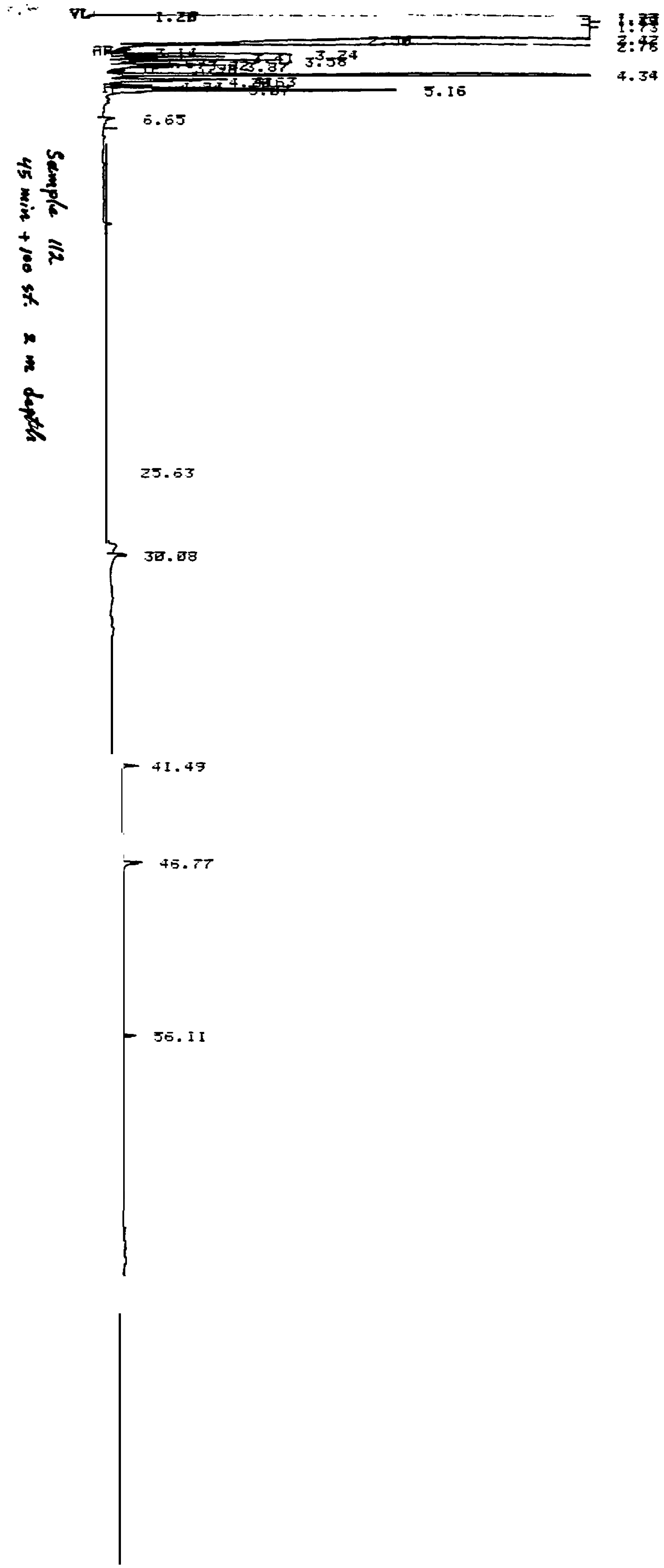
182

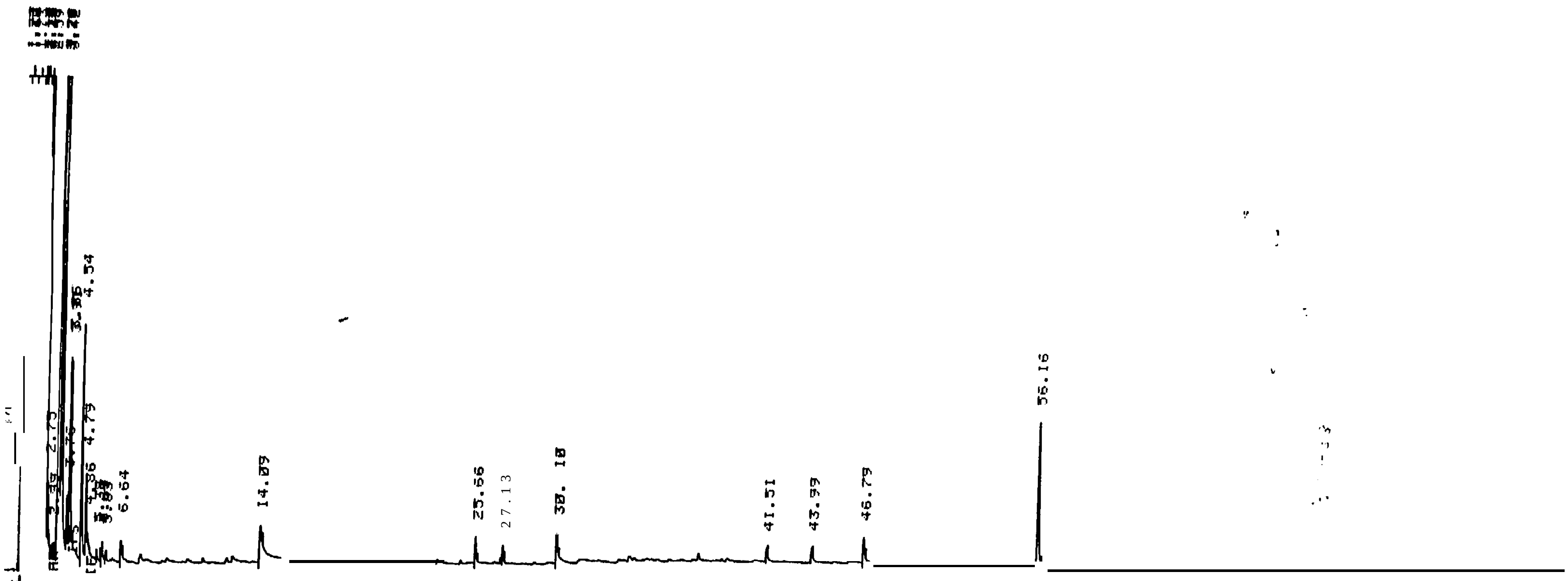
183


VL
4.37
5.19
9.17
8.76
10.38
15.93
26.69
30.13
35.86
41.53
44.00
45.22
46.81
56.18
Sample 116
85 min + 100 ST. 2 meters 7/20/88

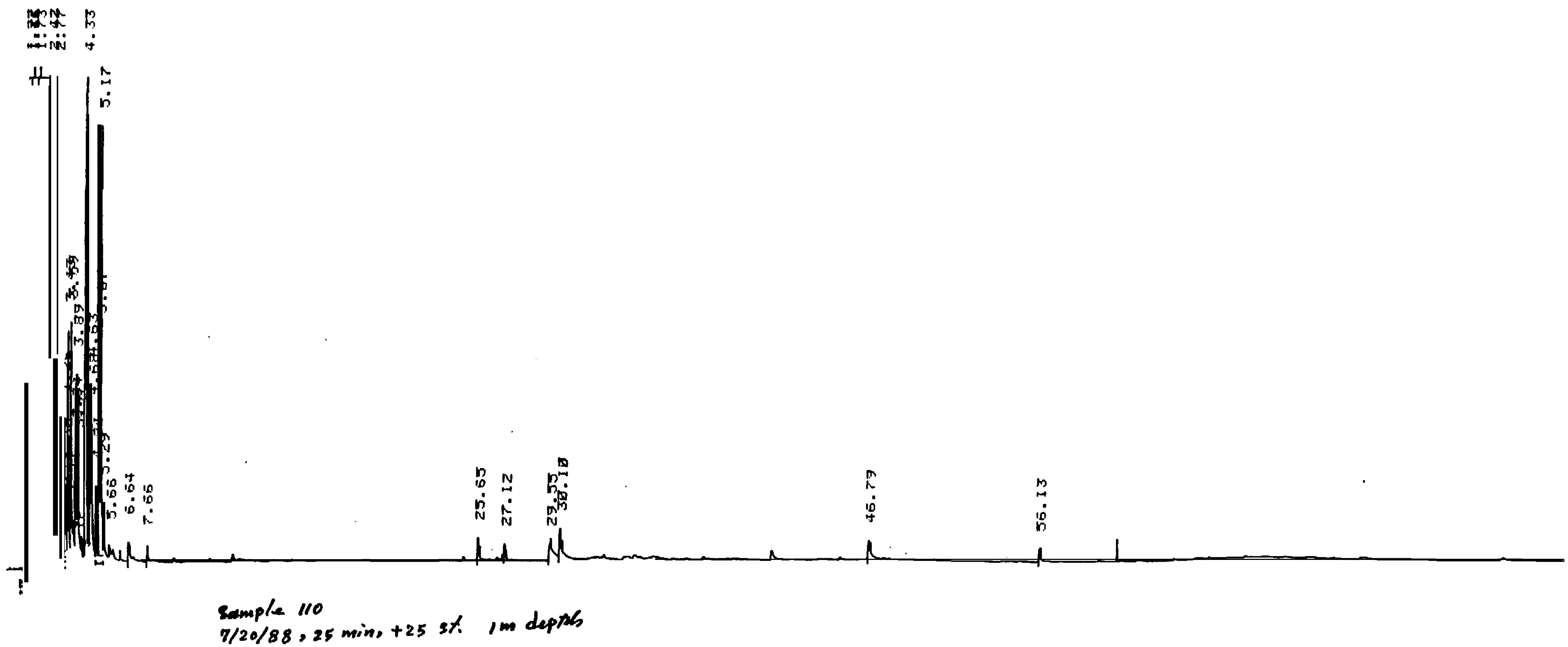


Sample 115
85 min. + 100 st. 4m deepths

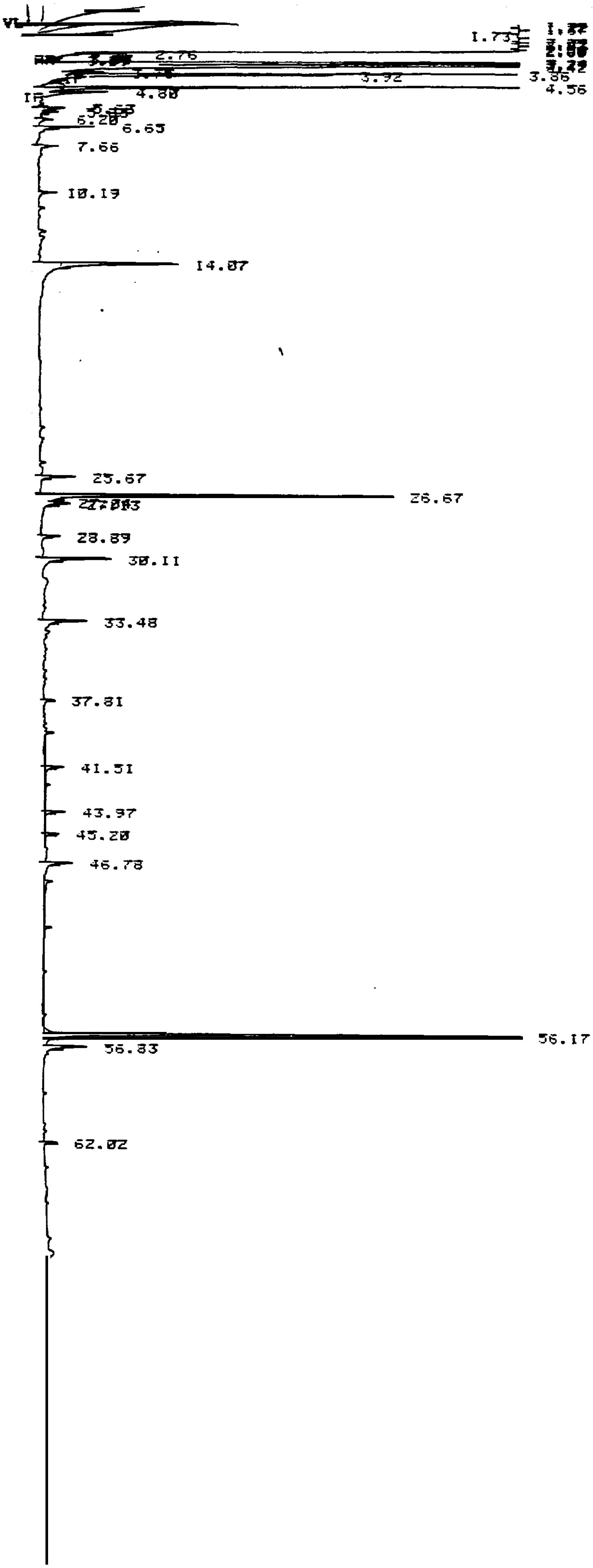

Sample 112
45 min + 100 st. 2 m depth
1.28
4.34
5.16
6.65
25.63
30.08
41.49
46.77
56.11

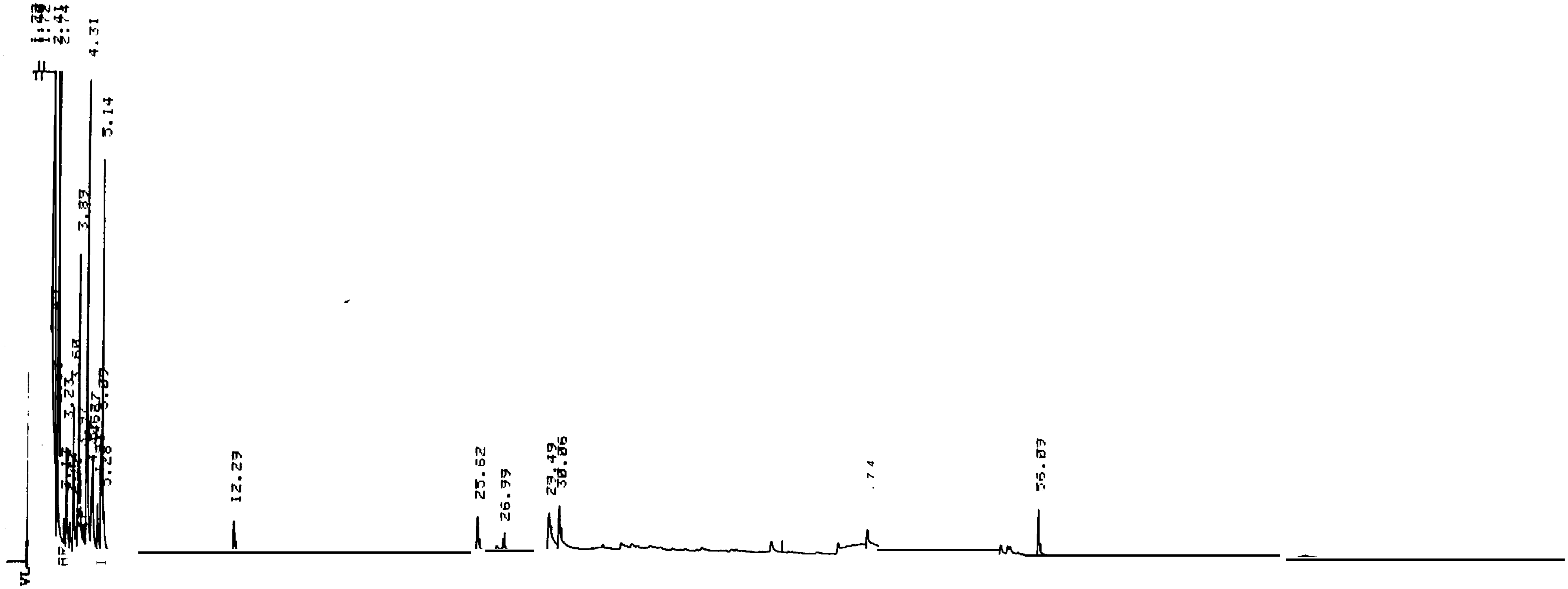


Sample III
7-20-88, 45 min., ef.+100, 4 m


5.17
4.33
3.89
5.66
6.64
7.66
25.65
27.12
29.55
30.10
46.79
56.13
Sample 110
7/20/88 , 25 min, +25 st. 1m depth

Sample 109
7/20/88, sf. + 25, 25 min, 4 m

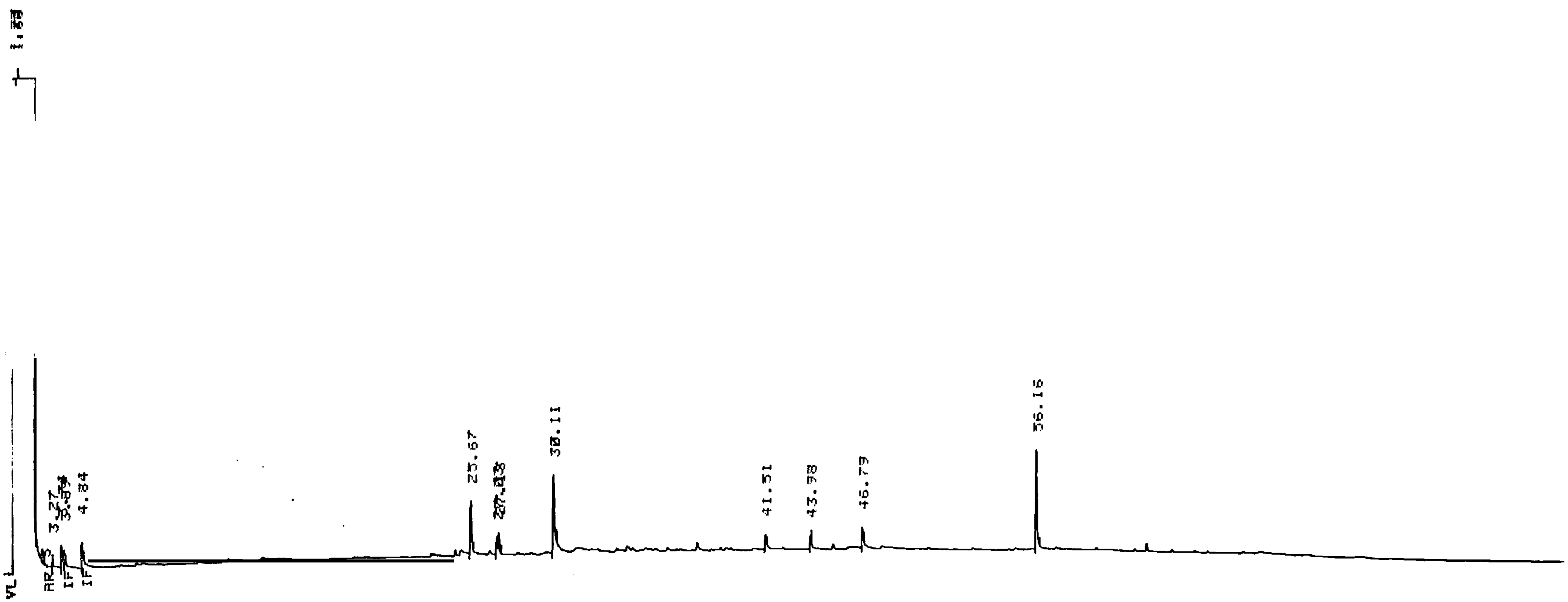




Sample 108
Time 0, -25 st., 1 m depths, 7,20,88

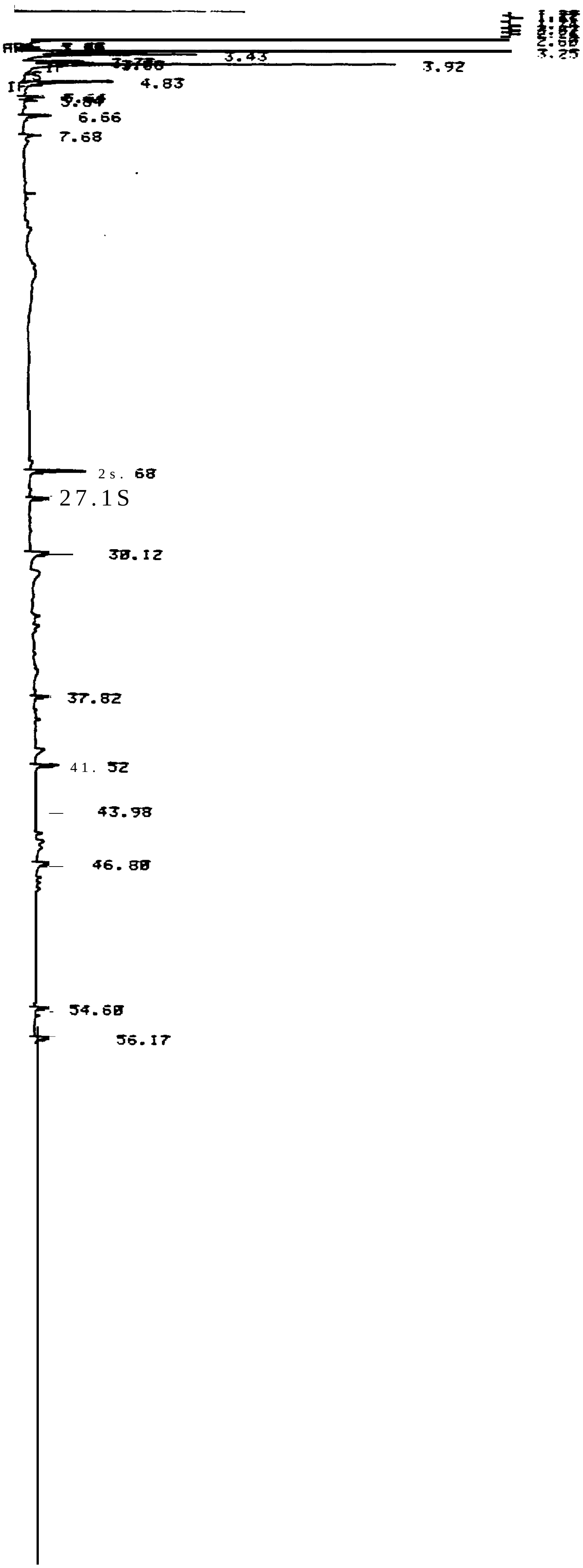
63

64

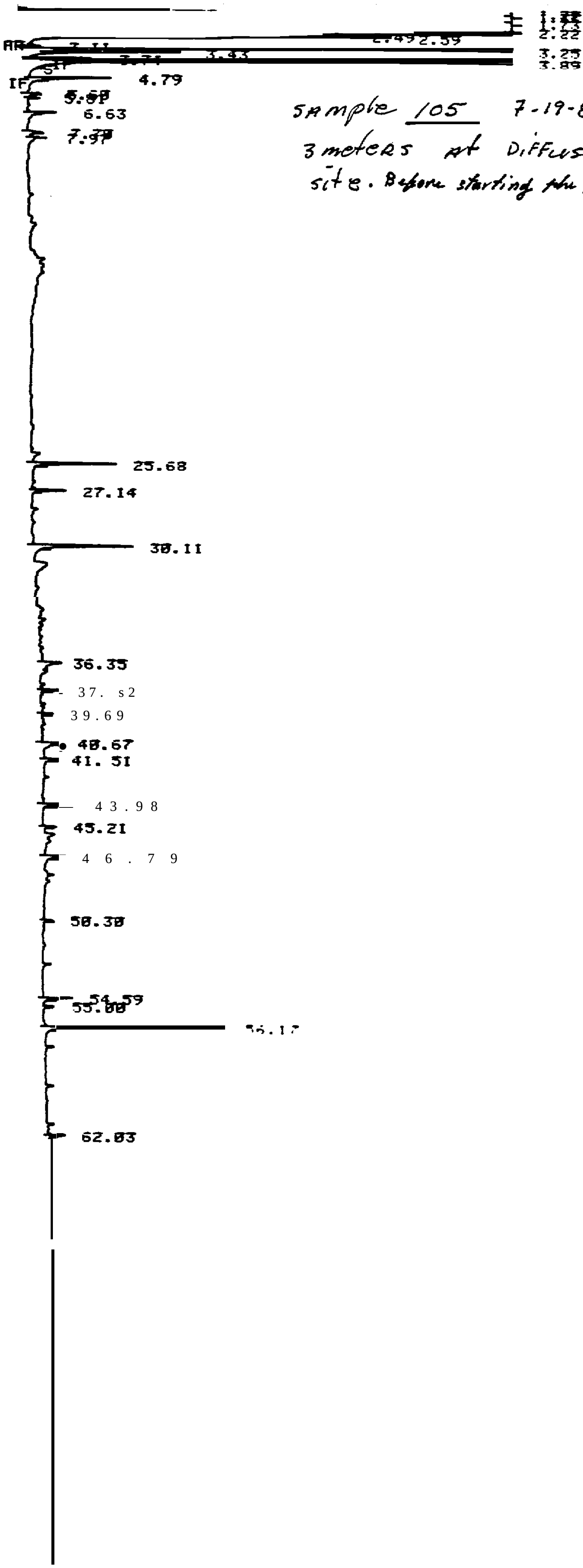


Sample 107
7,20,88 , st. -25 m , Time 0, 4 m

Sample 106
7/19/88 100 from diffuser site, 9 ft deep.
1 h after start ofu pump

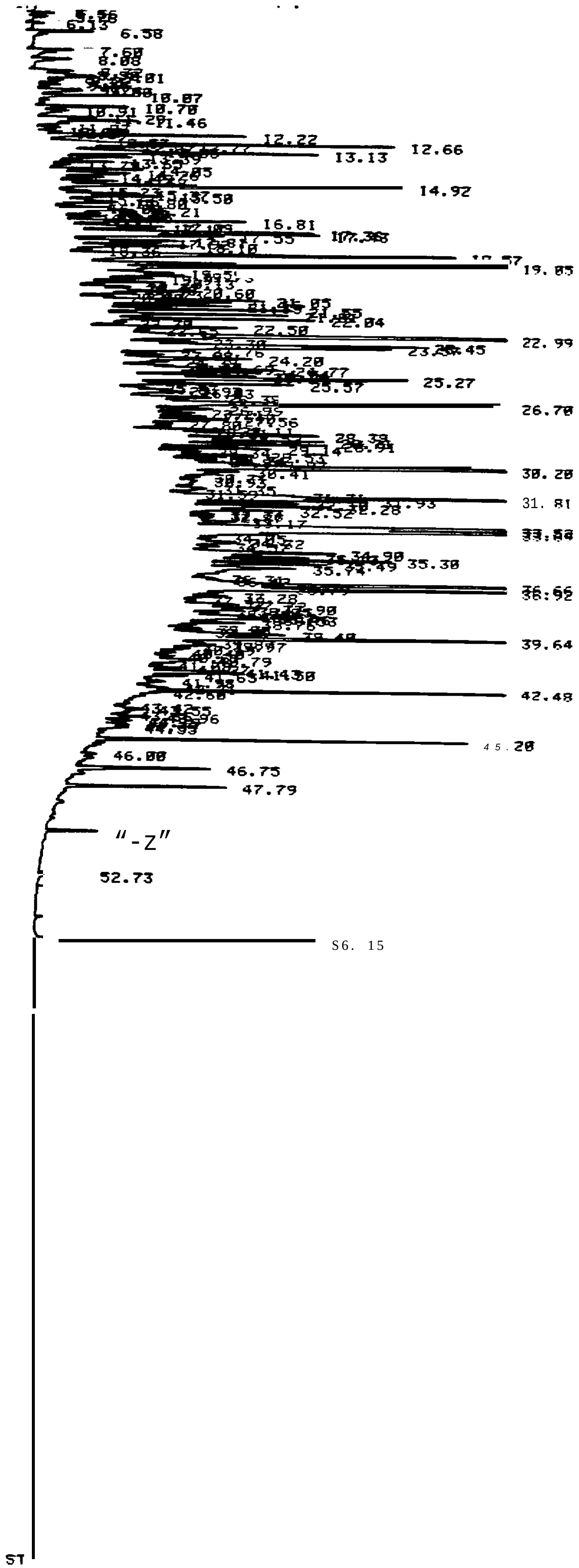


sample 105 7-19-88
3 meters at Diffuser
site. Before starting the pump.



168

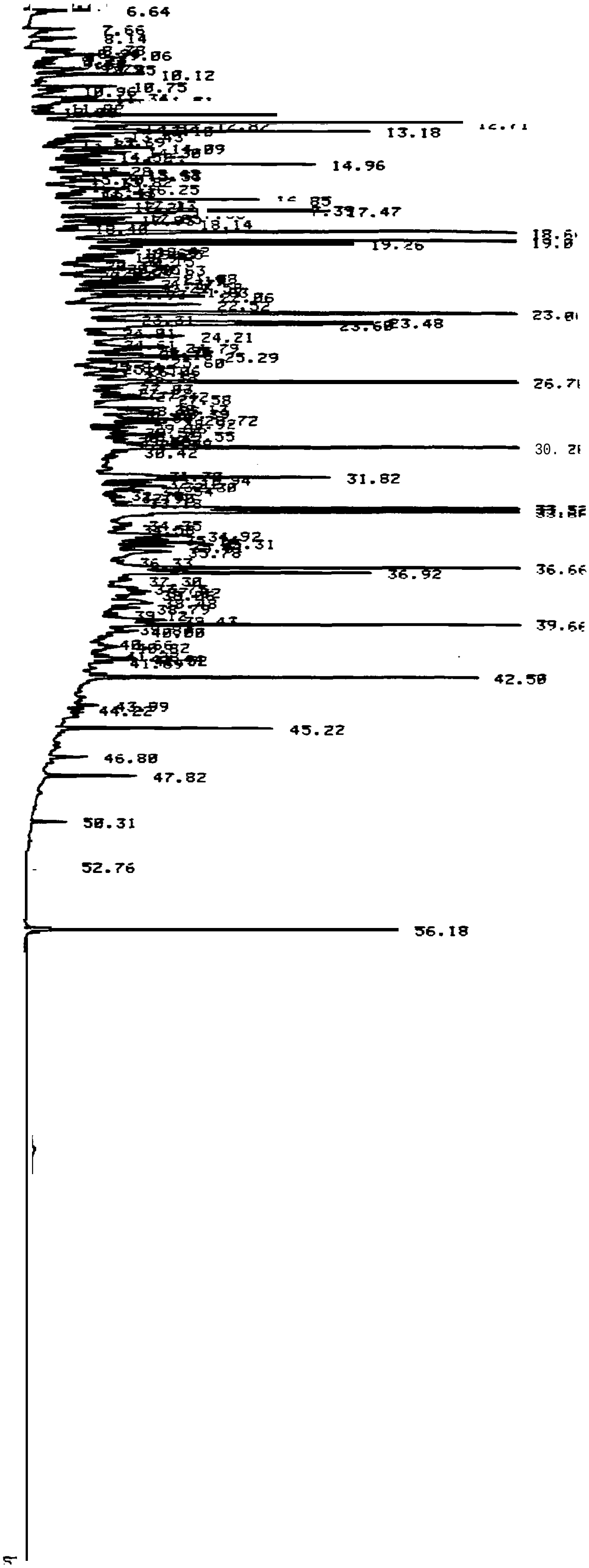
Sample 103
Jakolof Bay

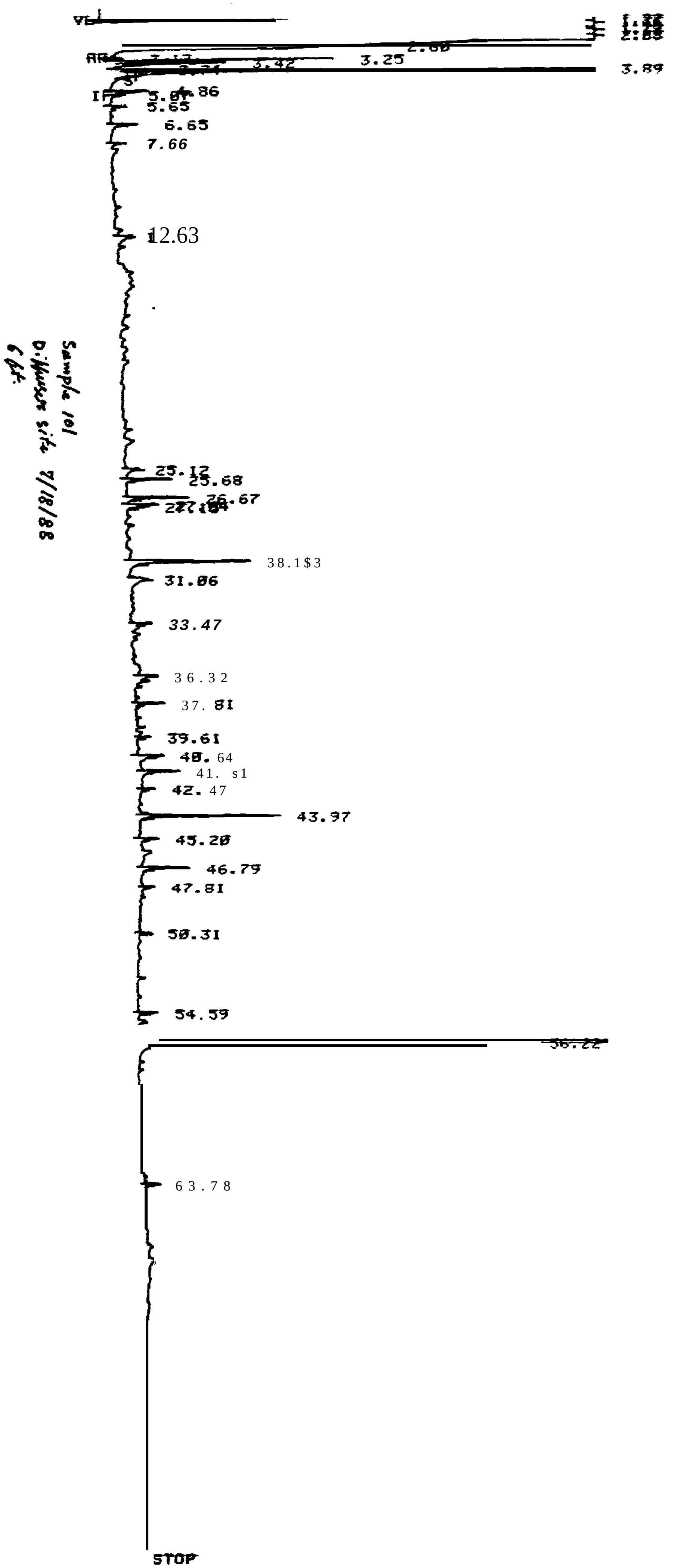


169

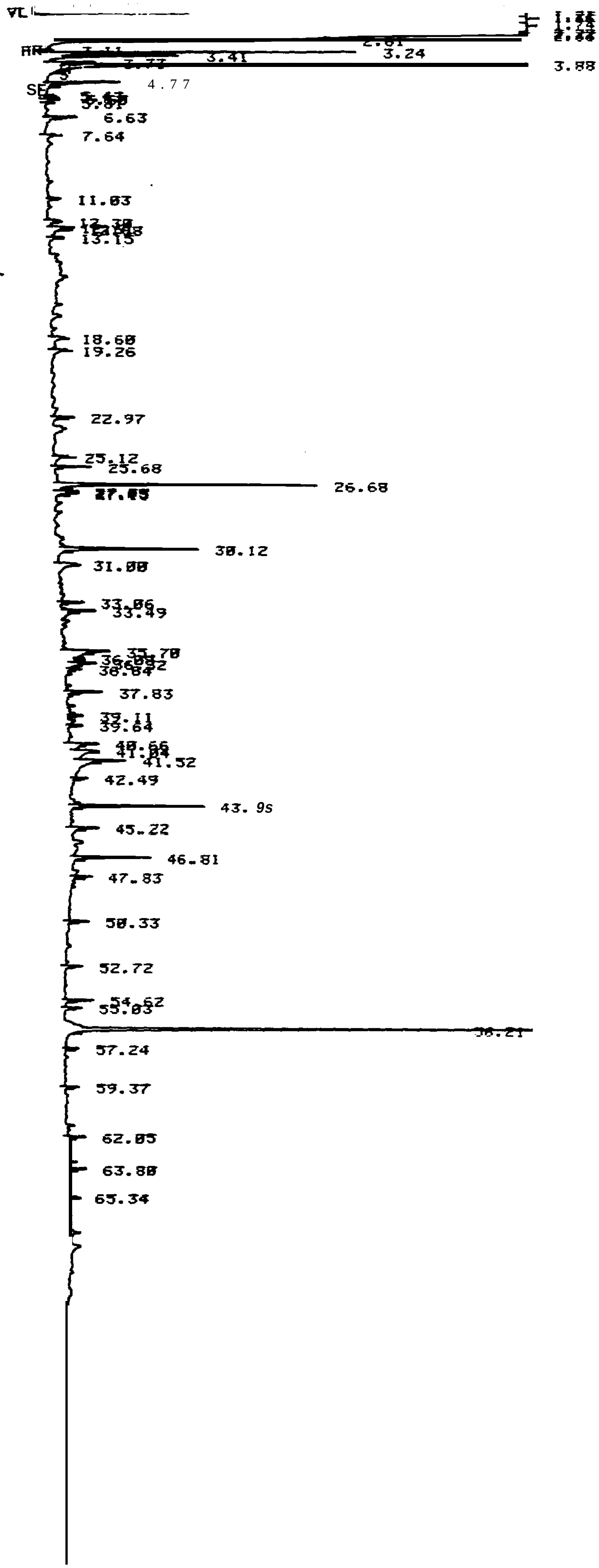
Sample 102
7/18/88, Barge loading site,
subsurface.

145




Sample 101
Diffuser site 7/18/88
6 ft.
3.25
3.89
5.65
6.65
7.66
12.63
25.12
25.68
26.67
31.06
33.47
36.32
39.61
42.47
43.97
45.20
46.79
47.81
50.31
54.59
63.78
STOP

Sample 100
7/18/88, 2 meters depth
diffuser site.



APPENDIX C

APPENDIX C

SONIC TAG IDENTIFICATION INFORMATION AND DISPOSITION OF PINK SALMON TAKEN FROM THE MOUTH OF JAKOLOF CREEK DURING SUMMER 1988

Appendix C

SONIC TAG IDENTIFICATION INFORMATION AND DISPOSITION OF PINK SALMON TAKEN FROM
THE MOUTH OF JAKOLOF CREEK DURING SUMMER 1988

Fish			Sonic Tag			Date				
Number	Sex (M-F)	Length (cm)	Tag No.	Frequency (Khz)	Serial No.	Fish Captured	Fish Tagged	Fish Released	Tag Recovered	Experiment No.
1	F	44	Xl	76	--	7/15	7/16	7/16	7/27	Test 1
2	F	50	x2	..	--	"	"	7/17	..	Test 2
3	F	50	11	76	--	"	7/19	7/19	..	Control 1
4	M	51	0	77	--	"	"	"	..	"
5	M	60	28	72	19	"	"	"	..b	"
6	M	47	0	73	..	"	"	"	..	"
7	M	54	25	73	..	"	"	"	..	"
8	M	49	10	46	18	"	"	"	7/22	"
9	M	56	7	44	..	"	"	"	..	"
10	M	49	21	50	6	"	"	"	7/24	"
11	M	.48	0	51	..	"	"	"	..	"
12	M	57	27	71	..	"	"	"	..	"
13	F	51	18	45	15	"	7/20	7/20	7/'24	Treatment 1
14	M	48	29	75	3	"	"	"	..	"
15	F	48	30	74	1	"	"	"	..	"
16	M	47	5	46	8	"	"	"	..	"
17	F	50	0	52	11	"	"	"	--	"
18	M	46	1	71	16	"	"	"	..	"
19	M	51	9	45	12	"	"	"	..	"
20	F	52	6	71	14	"	"	"	7/27	"
21	M	49	7	47	21	"	"	"	..	"
22	F	49	0	50	9	"	"	"	..	"
23	M	47	15	46	24	7/22	7/22	7/23	..	Control 2
24	F	45	10	46	18	"	"	"	b	"
25	F	52	17	42	31	"	"	"	7/27	"
26	M	49	0	40	26	"	"	"	..	"
27	F	42	0	71	22	"	"	"	..	"
28	M	49	18	76	23	"	"	"	--	"
29	F	53	2	52	27	"	"	"	--	"
30	M	58	31	75	28	"	"	"	..	"
31	F	43	0	53	29	"	"	"	..	"
32	F	47	0	51	30	"	"	"	..b	"
33	F	47	0	53	32	"	7/23	7/24	..	Control 2R
34	M	51	23	74	33	"	"	"	..	"
35	F	54	8	45	34	"	"	"	--	"
36	F	53	28	72	35	"	"	"	..	"
37	M	49	5	44	36	"	"	"	..b	"
38	M	48	9	46	37	"	"	"	..	"
39	M	56	20	72	38	"	"	"	..	"
40	F	49	27	73	39	"	"	"	--	"

Appendix C, Continued

Fish			Sonic Tag			Date				
Number	Sex (M-F)	Length (cm)	Tag No.	Frequency (Khz)	Serial No.	Fish Captured	Fish Tagged	Fish Released	Tag Recovered	Experiment No.
41	F	47	0	67	40	7/22	7/23	7/24	--	Control 2R
42	M	48	0	55	41	"	"	"	--	"
43	M	46	0	52	47	7/24	7/24	7/25	--	Treatment 2
44	F	50	21	50	6	"	"	"	--	"
45	F	51	24	71	43	"	"	"	--	"
46	M	47	19	76	42	"	"	"	--	"
47	F	49	3	46	44	"	"	"	--	"
48	F	45	0	67	45	"	"	"	--	"
49	F	51	20	50	46	"	"	"	--	"
50	F	53	24	50	48	"	"	"	--	"
51	F	53	14	46	49	"	"	"	--	"
52	F	46	23	52	50	"	"	"	--	"
53	M	41	15	47	66	7/27	7/27	7/28	--	Control 3
54	M	49	2	47	65	"	"	"	--	"
55	M	57	5	48	72	"	"	"	--	"
56	M	52	4	47	60	"	"	"	--	"
57	M	50	0	54	64	"	"	"	--	"
58	F	50	13	48	63	"	"	"	--	"
59	M	48	16	44	56	"	"	"	--	"
60	F	47	8	46	58	"	"	"	--	"
61	M	53	0	75	55	"	"	"	--	"
62	M	50	6	47	60	"	"	"	--	"
63	M	52	0	47	61	"	"	"	--	"
64	F	44	1	47	54	"	"	"	--	"
65	M	55	20	72	51	"	"	"	--	"
66	M	45	1	43	57	"	"	Mortality[a]	7/29	"
67	F	53	0	72	59	"	"	7/28	--	"
68	M	48	3	47	67	"	"	"	--	"
69	M	54	7	46	62	"	"	"	--	"
70	F	55	0	48	69	"	"	"	--	"
71	F	49	14	47	71	"	"	"	--	"
72	M	53	11	47	70	"	"	"	--	"
73	F	52	22	73	23	"	7/28	7/29	--	Treatment 3
74	M	42	4	45	80	"	"	U	--	"
75	M	47	3	74	73	"	"	"	--	"
76	F	54	4	46	72	"	"	"	--	"
77	M	44	13	46	85	"	"	"	--	"
78	M	46	30	76	77	"	"	"	--	"
79	M	47	0	49	74	"	"	"	--	"
80	F	53	0	70	82	7/27	7/28	7/29	--	"
81	M	50	22	49	79	"	"	"	--	"
82	F	50	26	75	88	"	"	"	--	"
83	M	49	31	74	91	"	"	"	--	"
84	M	57	16	42	87	"	"	"	--	"
85	M	60	7	74	89	"	"	"	--	"
86	M	45	1	72	86	"	"	"	--	"

Appendix C, Concluded

Fish			Sonic Tag			Date				
Number	Sex (M-F)	Length (cm)	Tag No.	Frequency (Khz)	Serial No.	Fish Captured	Fish Tagged	Fish Released	Tag Recovered	Experiment No.
87	F	47	0	50	84	"	"	"	..[b]	Treatment 3
88	F	51	30	72	75	7/27	7/28	7/29	--	"
89	M	50	1	76	76	"	"	"	..	"
90	F	50	6	45	90	"	"	"	..	"
91	M	47	25	72	81	"	"	"	..	"
92	F	50	12	46	78	"	"	Mortality[a]	7/29	"

[a] Fish died due to entanglement in net pen.

[b] Tag recovered from Jakolof Creek after the experiment was completed.

APPENDIX D

APPENDIX D

HORIZONTAL POSITION (X Y), DEPTH, AND HYDROCARBON CONCENTRATION BY TIME FOR EACH FISH

Appendix D-1

Horizontal Position (X, Y) and Depth
by Fish and Time During Control 1

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
3	2033.0	1640	625	0.15	4	2051.0	1938	429	3.51
	2034.0	1648	601	1.98		2052.0	1972	433	3.66
	2035.0	1653	593	2.90		2053.0	2002	438	3.66
	2036.0	1659	588	3.05		2054.0	2038	443	3.66
	2037.0	1667	577	3.20		2055.0	2069	449	3.51
	2038.0	1673	541	3.20		2056.0	2098	455	3.36
	2039.0	1681	521	3.36	5	2034.0	1641	595	2.29
	2040.0	1689	499	3,36		2035.0	1644	578	2.75
	2041.0	1716	468	3.51		2036.0	1649	555	3.20
	2042.0	1730	453	3.51		2037.0	1653	534	3.20
	2043.0	1746	440	3.51		2038.0	1658	511	3.36
	2044.0	1761	430	3.66		2039.0	1663	485	3.36
	2045.0	1791	414	3.66		2040.0	1670	462	3.36
	2046.0	1778	444	3.51		2041.0	1679	436	3.51
	2047.0	1812	439	3.66		2042.0	1691	410	3.36
	2048.0	1852	442	3.81		2043.0	1708	393	3.36
	2049.0	1893	449	3.66		2044.0	1735	382	3.51
	2050.0	1923	445	3.66		2045.0	1767	381	3.66
	2051.0	1961	447	3.51		2046.0	1804	385	3.66
	2052.0	1996	449	3.36		2047.0	1836	394	3.81
	2053.0	2031	451	3.36		2048.0	1873	401	3.81
	2054.0	2059	455	3.51		2049.0	1907	409	3.51
	2055.0	2127	460	3.66		2050.0	1946	424	3.51
4	2034.0	1647	600	1.53		2051.0	1985	429	3.66
	2035.0	1651	591	2.29		2052.0	2025	432	3.66
	2036.0	1653	564	3.05		2053.0	2062	435	3.51
	2037.0	1658	572	3.20		2054.0	2099	438	3.51
	2038.0	1663	60	3.05	6	2034.0	1644	597	1.98
	2039.0	1669	541	3.36		2035.0	1646	593	2.90
	2040.0	1676	525	3.51		2036.0	1648	580	2.90
	2041.0	1683	505	3.36		2037.0	1652	563	3.05
	2042.0	1694	482	3.36		2038.0	16!57	542	3.20
	2046.0	1792	418	3.51		2039.0	1664	518	3.36
	2047.0	1800	418	3.66		2040.0	1670	492	3.36
	2048.0	1830	416	3.66		2041.0	1679	472	3.51
	2049.0	1868	416	3.51		2042.0	1694	475	3.66
	2050.0	1897	419	3.51		2043.0	1708	482	3.66

Appendix **D-1**

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
6	2044.0	1725	466	3.81	7	2101.0	1701	532	3.97
	2045.0	1756	447	3.81		2102.0	1715	531	3.81
	2046.0	1795	422	3.81		2103.0	1729	530	3.81
	2047.0	1822	418	3.36		2104.0	1744	528	3.66
	2048.0	1856	415	3.36		2105.0	1759	525	3.66
	2049.0	1893	411	3.51		2106.0	1775	524	3.66
	2050.0	1963	435	3.66		2107.0	1792	523	3.51
	2051.0	2002	439	3.66		2108.0	1810	517	3.51
	2052.0	2043	441	3.66		2109.0	1826	516	3.66
	2053.0	2076	446	3.81		2110.0	1841	510	3.51
	2054.0	2112	453	3.66		2111.0	1658	501	3.66
7	2034.0	1643	604	3.05		2112.0	1876	489	3.81
	2035.0	1634	617	3.51		2113.0	1889	483	3.66
	2036.0	1634	603	3.81		2114.0	1915	480	3.66
	2037.0	1631	600	3.97		2115.0	1933	475	3.51
	2038.0	1629	598	4.12		2116.0	1953	469	3.36
	2039,0	1627	595	4.12		2117.0	1971	464	3.51
	2040.0	1626	586	3.97		2118.0	1991	461	3.66
	2041.0	1623	584	3.97		2119.0	2016	456	3.66
	2042.0	1621	582	4.12		2120.0	2048	453	3.81
	2043.0	1620	576	4.27		2121.0	2087	452	3.81
	2044.0	1617	566	4.42		2122.0	2124	453	3.81
	2045.0	1617	563	4.58	8	2034.0	1645	598	1.98
	2046.0	1618	559	4.73		2035.0	1649	585	2.59
	2047.0	1618	555	4.73		2036.0	1654	573	2.75
	2048.0	1621	554	4.73		2037.0	1659	556	2.90
	2049.0	1625	554	4.88		2038.0	1664	538	3.05
	2050.0	1624	549	4.73		2039.0	1670	523	3.20
	2051.0	1624	546	4.58		2040.0	1680	507	3.20
	2052.0	1628	547	4.58		2041.0	1698	489	3.36
	2053.0	1630	545	4.58		2042.0	1722	478	3.36
	2054.0	1633	544	4.42		2048.0	1931	472	3.20
	2055.0	1638	543	4.58		2049.0	1965	471	3.36
	2056.0	1641	541	4.73		2050.0	1999	470	3.51
	2057.0	1649	539	4.42		2051.0	2032	468	3.51
	2058.0	1659	537	4.27		2052.0	2073	469	3.66
	2059.0	1672	534	3.97		2053.0	2114	468	3.51
	2100.0	1685	534	4.12	9	2034.0	1641	602	2.29

Appendix **D-1**

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
9	2035.0	1643	590	3.05	10	2049.0	1921	434	3.66
	2036.0	1645	575	3.36		2050.0	1961	436	3.66
	2037.0	1649	559	3.51		2051.0	2001	436	3.81
	2038.0	1653	541	3.51		2052.0	2040	437	3.66
	2039.0	1653	524	3.66		2053.0	2081	438	3.51
	2040.0	1659	505	3.81		2054.0	2112	437	3.51
	2041.0	1663	490	3.97	11	2034.0	1643	604	2.44
	2042.0	1669	467	3.97		2035.0	1647	588	2.90
	2043.0	1677	445	3.97		2036.0	1651	575	3.20
	2044.0	1696	426	3.81		2037.0	1656	557	3.36
	2045.0	1716	411	3.66		2038.0	1660	543	3.36
	2046.0	1745	402	3.66		2039.0	1666	525	3.66
	2047.0	1774	399	3.51		2040.0	1670	502	3.81
	2048.0	1805	404	3.51		2041.0	1678	483	3.81
	2049.0	1834	406	3.81		2042.0	1686	460	3.66
	2050.0	1871	409	3.81		2043.0	1695	441	3.51
	2051.0	1903	411	3.66		2044.0	1709	419	3.51
	2052.0	1944	422	3.66		2045.0	1727	404	3.36
	2053.0	1980	426	3.51		2046.0	1753	397	3.36
	2054.0	2018	431	3.66		2047.0	1780	398	3.36
	2055.0	2051	434	3.81		2048.0	1813	401	3.51
	2056.0	2085	439	3.66		2049.0	1836	414	3.66
	2057.0	2116	443	3.66		2050.0	1864	418	3.66
10	2034.0	1647	607	1.83		2051.0	1891	422	3.81
	2035.0	1653	598	2.59		2052.0	1929	438	3.51
	2036.0	1660	584	2.90		2053.0	1966	448	3.51
	2037.0	1668	571	3.05		2054.0	2000	453	3.66
	2038.0	1675	559	3.20		2055.0	2033	459	3.66
	2039.0	1682	547	3.20		2056.0	2079	465	3.81
	2040.0	1690	536	3.51		2057.0	2122	469	3.66
	2041.0	1700	519	3.51	12	2034.0	1644	597	2.14
	2042.0	1712	503	3.66		2035.0	1647	580	2.90
	2043.0	1725	486	3.66		2036.0	1651	65	3.20
	2044.0	1745	464	3.51		2037.0	1655	546	3.51
	2045.0	1770	445	3.36		2038.0	1660	528	3.51
	2046.0	1798	433	3.36		2039.0	1667	509	3.66
	2047.0	1838	423	3.36		2040.0	1676	491	3.66
	2048.0	1877	424	3.51		2041.0	1698	481	3.81

Appendix **D-1**

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)
12	2042.0	1713	468	3.51
	2043.0	1723	450	3.36
	2044.0	1744	437	3.36
	2045.0	1766	425	3.20
	2046.0	1792	414	3.36
	2047.0	1822	409	3.51
	2048.0	1856	409	3.51
	2049.0	1894	414	3.66
	2050.0	1935	426	3.66
	2051.0	1969	433	3.66
	2052.0	2004	440	3.81
	2053.0	2041	447	3.66
	2054.0	2072	452	3.51
	2055.0	2101	453	3.36
	2056.0	2128	455	3.51

Appendix D-2

Horizontal Position (X, Y) and Depth
by Fish and Time During Control 2

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
33	1328.0	1645	606	0.31	33	1406.0	2115	435	4.58
	1329.0	1647	594	1.22		1407.0	2131	441	4.58
	1330.0	1650	586	2.59		1408.0	2149	442	4.73
	1331.0	1651	578	3.05		1409.0	2164	446	4.27
	1332.0	1654	562	3.05		1410.0	2178	451	4.27
	1333.0	1658	545	3.20		1411.0	2192	468	4.12
	1334.0	1655	521	3.51		1412.0	2211	500	3.66
	1335.0	1653		3.66		1413.0	2233	475	3.81
	1336.0	1649	487	3.97		1415.0	2292	478	3.51
	1337.0	1644	467	4.42		1416.0	2319	479	3.51
	1338.0	1640	446	4.58		1417.0	2365	475	3.66
	1339.0	1643	430	4.58		1418.0	2385	481	3.66
	1340.0	1651	417	4.88	34	1329.0	1643	596	1.98
	1341.0	1662	413	5.03		1330.0	1643	585	3.36
	1342.0	1672	408	5.03		1331.0	1643	581	3.20
	1343.0	1684	407	4.88		1332.0	1644	571	3.20
	1344.0	1695	405	5.03		1333.0	1644	555	3.36
	1345.0	1709	404	4.88		1334.0	1643	538	3.66
	1346.0	1721	401	4.73		1335.0	1640	515	3.51
	1347.0	1732	399	4.73		1336.0	1636	498	3.66
	1348.0	1741	400	4.88		1337.0	1636	482	3.81
	1349.0	1751	399	4.58		1338.0	1633	465	4.12
	1350.0	1762	400	4.42		1339.0	1635	452	4.12
	1352.0	1788	402	3.97		1340.0	1638	437	4.27
	1353.0	1812	407	3.66		1341.0	1641	427	4.42
	1354.0	1836	413	3.51		1342.0	1644	419	4.42
	1355.0	1858	415	3.36		1343.0	1648	413	4.58
	1356.0	1889	417	3.05		1344.0	1650	404	4.42
	1357.0	1921	425	3.20		1345.0	1658	395	4.42
	1358.0	1949	426	3.20		1346.0	1664	390	4.42
	1359.0	1977	429	3.36		1347.0	1676	390	4.27
	1400.0	2001	432	3.51		1348.0	1678	383	4.42
	1401.0	2024	433	3.81		1349.0	1686	379	4.27
	1402.0	2044	438	4.27		1350.0	1699	379	4.12
	1403.0	2061	441	4.73		1351.0	1714	375	4.12
	1404.0	2078	442	4.73		1352.0	1738	377	3.97
	1405.0	2099	435	4.58		1353.0	1760	381	3.81

Appendix D-2

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
34	1354.0	1781	387	3.66	35	1336.0	1618	497	3.97
	1355.0	1802	394	3,66		1337.0	1610	484	3.81
	1356.0	1826	401	3.36		1338.0	1604	471	3.97
	1357.0	1849	408	3.36		1339.0	1597	455	4.12
	1358.0	1878	415	3.51		1340.0	1596	441	4.42
	1359.0	1904	422	3.36		1341.0	1596	433	4.42
	1400.0	1935	432	3.20		1342.0	1598	426	4.58
	1401.0	1951	434	3.51		1343.0	1601	419	4.58
	1402.0	1964	438	3.66		1345.0	1611	408	4.88
	1403.0	1976	440	3.81		1346.0	1616	405	4.88
	1404.0	1987	441	3.97		1347.0	1622	403	4.58
	1405.0	2000	444	3.97		1348.0	1628	401	4.42
	1406.0	2012	448	4.12		1349.0	1635	401	4.42
	1407.0	2023	450	4.12		1350.0	1641	398	4.27
	1408.0	2033	451	3.97		1351.0	1651	399	4.12
	1409.0	2043	453	3.97		1352.0	1671	401	3.81
	1410.0	2053	454	3.81		1353.0	1699	406	3.66
	1411.0	2062	456	3.51		1354.0	1723	410	3.36
	1412.0	2072	458	3.36		1355.0	1754	412	3.51
	1413.0	2089	459	3.51		1357.0	1821	411	3.66
	1414.0	2106	461	3.36		1358.0	1855	405	3.81
	1415.0	2123	466	3.36		1359.0	1886	404	3.97
	1416.0	2142	465	3.20		1400.0	1908	402	4.12
	1417.0	2165	464	3.20		1401.0	1930	407	4.27
	1418.0	2190	467	3.36		1402.0	1945	405	4.42
	1419.0	2219	469	3.51		1403.0	1953	402	4.27
	1420.0	2251	490	3.51		1404.0	1966	402	4.27
	1421.0	2277	490	3.51		1405.0	1979	400	4.42
	1422.0	2301	487	3.66		1406.0	1991	400	4.58
	1423.0	2333	487	3.51		1407.0	2003	400	4.42
	1424.0	2359	488	3.36		1408.0	2018	399	4.42
	1425.0	2383	491	3.36		1409.0	2032	400	4.27
35	1329.0	1640	588	1.53		1410.0	2046	400	4.42
	1330.0	1639	582	2.59		1411.0	2063	404	4.27
	1331.0	1637	573	3.05		1412.0	2085	406	4.27
	1332.0	1635	561	3.36		1413.0	2109	413	4.12
	1333.0	1631	541	3.51		1414.0	2139	420	3.97
	1334.0	1629	528	3.66		1415.0	2170	428	3.97
	1335.0	1622	510	3.66		1416.0	2202	436	3.81

Appendix D-2

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
35	1417.0	2235	445	3.66	36	1349.0	1772	408	4.73
	1418.0	2266	470	3.51		1350.0	1782	410	4.58
	1419.0	2293	470	3.66	37	1351.0	1792	411	4.42
	1420.0	2315	469	3.81		1352.0	1806	413	4.27
	1421.0	2335	470	3.66		1353.0	1827	417	4.12
	1422.0	2355	469	3.66		1354.0	1853	421	3.97
	1423.0	2379	470	3.51		1355.0	1882	424	3.66
	1424.0	2401	472	3.66		1356.0	1901	429	3.81
36	1329.0	1637	591	1.37		1357.0	1931	437	3.66
	1330.0	1632	577	1.98		1358.0	1956	443	3.51
	1331.0	1625	563	2.59		1359.0	1982	446	3.36
	1332.0	1618	546	2.44		1400.0	2009	449	3.51
	1333.0	1609	525	2.59		1401.0	2030	450	3.81
	1334.0	1592	498	2.75		1402.0	2047	450	3.97
	1336.0	1534	486	2.90		1403.0	2065	450	4.12
	1337.0	1504	487	3.05		1404.0	2080	450	4.27
	1338.0	1470	493	2.90		1405.0	2094	450	4.27
	1339.0	1423	499	2.75		1406.0	2104	450	4.42
	1340.0	1345	506	2.90		1407.0	2116	445	4.27
37	1329.0	1644	605	1.07		1408.0	2131	445	4.27
	1330.0	1647	594	2.14		1409.0	2146	443	3.97
	1331.0	1652	587	2.90		1410.0	2165	442	3.81
	1332.0	1656	571	3.20		1411.0	2184	440	3.66
	1333.0	1660	550	3.51		1412.0	2207	441	3.66
	1334.0	1661	530	3.66		1413.0	2238	442	3.81
	1335.0	1654	504	3.97		1414.0	2266	467	3.66
	1336.0	1651	485	3.97		1415.0	2287	465	3.66
	1337.0	1649	469	3.81		1416.0	2313	463	3.51
	1338.0	1646	449	3.97		1417.0	2347	465	3.66
	1339.0	1647	429	4.12		1418.0	2385	469	3.81
	1340.0	1658	414	4.42	38	1329.0	1642	603	1.98
	1341.0	1667	409	4.42		1330.0	1640	601	2.75
	1342.0	1676	405	4.58		1331.0	1640	587	3.05
	1343.0	1688	404	4.73		1332.0	1639	565	3.36
	1344.0	1703	403	4.73		1333.0	1633	539	3.51
	1345.0	1719	402	4.88		1334.0	1634	516	3.51
	1346.0	1732	404	5.03		1335.0	1635	494	3.66
	1347.0	1745	405	4.88		1336.0	1635	474	3.51
	1348.0	1761	406	4.58		1337.0	1638	452	3.81

Appendix D-2

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
38	1339.0	1657	403	4.12	39	1331.0	1637	85	3.36
	1340.0	1677	389	4.42		1332.0	1635	565	3.36
	1341.0	1689	383	4.58		1333.0	1628	544	3.51
	1342.0	1703	382	4.73		1334.0	1622	519	3.66
	1343.0	1719	376	4.73		1335.0	1612	496	3.66
	1344.0	1734	372	4.88		1336.0	1607	478	4.12
	1345.0	1751	372	4.88		1337.0	1603	463	4.12
	1346.0	1769	372	4.88		1338.0	1600	453	4.27
	1347.0	1787	377	4.73		1339.0	1598	440	4.27
	1348.0	1803	382	4.73		1340.0	1601	428	4.27
	1349.0	1819	88	4.58		1341.0	1604	418	4.42
	1350.0	1836	393	4.58		1342.0	1610	408	4.58
	1351.0	1852	397	4.58		1343.0	1616	400	4.73
	1352.0	1871	399	4.42		1344.0	1622	392	4.88
	1353.0	1900	402	4.12		1345.0	1631	385	5.03
	1354.0	1935	411	3.97		1346.0	1639	381	4.88
	1355.0	1964	408	3.81		1347.0	1646	377	4.88
	1356.0	1987	405	3.66		1348.0	1652	373	4.73
	1357.0	2007	403	3.97		1349.0	1658	370	4.58
	1358.0	2031	399	4.12		1350.0	1664	367	4.73
	1359.0	2050	396	4.42		1351.0	1671	66	4.58
	1400.0	2069	394	4.58		1352.0	1671	366	4.58
	1401.0	2085	394	4.58		1353.0	1687	361	4.73
	1402.0	2102	391	4.42		1354.0	1695	359	4.73
	1403.0	2120	398	4.27		1355.0	1701	356	4.58
	1404.0	2142	402	4.27		1356.0	1709	355	4.42
	1405.0	2162	408	4.12		1357.0	1717	357	4.42
	1406.0	2179	411	3.97		1358.0	1731	355	4.27
	1407.0	2194	415	3.81		1359.0	1747	352	4.27
	1408.0	2212	419	3.66		1400.0	1762	354	4.42
	1409.0	2227	421	3.66		1401.0	1777	356	4.27
	1410.0	2244	425	3.51		1402.0	1786	367	4.12
	1412.0	2279	451	3.51		1403.0	1803	370	4.12
	1413.0	2301	450	3.36		1404.0	1817	374	3.97
	1414.0	2328	451	3.66		1405.0	1832	380	3.97
	1415.0	2365	452	3.81		1406.0	1851	385	4.12
	1416.0	2405	453	3.66		1407.0	1870	387	3.97
39	1329.0	1640	600	2.29		1408.0	1889	388	3.97
	1330.0	1639	593	3.20		1409.0	1912		3.81

Appendix D-2

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
39	1410.0	1940	396	3.66	40	1339.0	1680	471	4.27
	1411.0	1954	393	3.51		1340.0	1684	461	4.42
	1412.0	1969	392	3.36		1341.0	1685	449	4.42
	1413.0	1986	389	3.36		1342.0	1693	438	4.58
	1414.0	2001	387	3.51		1343.0	1697	426	4.73
	1415.0	2016	384	3.36		1344.0	1699	416	4.88
	1416.0	2030	380	3.51		1345.0	1706	404	4.88
	1417.0	2044	378	3.36		1346.0	1713	397	4.88
	1418.0	2059	374	3.51		1347.0	1720	392	4.73
	1419.0	2075	369	3.81		1348.0	1727	390	5.03
	1420.0	2091	371	4.12		1349.0	1734	388	4.88
	1421.0	2102	369	4.12		1350.0	1742	387	4.73
	1422.0	2115	370	4.27		1351.0	1749	385	4.58
	1423.0	2127	368	4.42		1352.0	1756	386	4.42
	1424.0	2140	365	4.42		1353.0	1765	389	4.58
	1425.0	2155	365	4.42		1354.0	1774	390	4.42
	1426.0	2168	366	4.27		1355.0	1782	395	4.42
	1427.0	2184	367	4.27		1356.0	1791	398	4.42
	1428.0	2198	369	4.12		1357.0	1801	403	4.27
	1429.0	2217	372	3.97		1358.0	1814	408	4.27
	1430,0	2233	375	3.97		1359.0	1828	415	4.27
	1431.0	2248	376	4.12		1400.0	1842	422	4.12
	1433.0	2281	383	3.81		1401.0	1855	427	3.97
	1434.0	2294	401	3.66		1402.0	1871	433	3.81
	1435.0	2306	407	3.51		1403.0	1890	438	3.66
	1436.0	2320	402	3.66		1404.0	1916	445	3.66
	1437.0	2334	409	3.81		1405.0	1942	448	3.51
	1438.0	2334	409	3.66		1406.0	1970	446	3.66
	1439.0	2357	441	3.81		1407.0	1997	445	3.97
40	1329.0	1644	605	2.44		1408.0	2025	444	4.12
	1330.0	1647	594	2.90		1409.0	2046	443	4.27
	1331.0	1650	586	2.90		1410.0	2064	442	4.42
	1332.0	1654	573	3.05		1411.0	2081	443	4.42
	1333.0	1658	561	3.20		1412.0	2103	439	4.58
	1334.0	1662	544	3.51		1413.0	2138	433	4.58
	1335.0	1667	527	3.81		1414.0	2169	424	4.42
	1336.0	1669	514	3.97		1415.0	2202	414	4.42
	1337.0	1674	502	4.12		1416.0	2224	409	4.27
	1338.0	1676	485	4.12		1417.0	2247	404	4.27

Appendix D-2

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
40	1418.0	2272	399	4.12	41	1403.0	1933	436	3.81
	1419.0	2299	409	3.97		1404.0	1960	442	3.81
	1420.0	2299	409	3.81		1405.0	1889	447	3.97
	1421.0	2342	430	3.81		1406.0	2012	449	4.12
	1422.0	2362	451	3.97		1407.0	2033	451	4.42
41	1329.0	1644	597	1.98		1408.0	2055	451	4.58
	1330.0	1643	586	2.75		1409.0	2079	451	4.58
	1331.0	1644	582	3.20		1410.0	2099	453	4.73
	1332.0	1645	568	3.20		1411.0	2116	455	4.73
	1333.0	1648	552	3.05		1412.0	2136	455	4.58
	1334.0	1649	535	3.20		1413.0	2153	455	4.42
	1335.0	1649	516	3.51		1414.0	2178	456	4.27
	1336.0	1653	502	3.81		1415.0	2207	456	3.97
	1337.0	1657	487	3.97		1416.0	2231	459	3.81
	1338.0	1659	466	3.97		1417.0	2252	482	3.81
	1339.0	1662	446	3.81		1418.0	2271	480	3.66
	1340.0	1665	427	3.97		1419.0	2289	478	3.51
	1341.0	1670	416	3.97		1420.0	2307	476	3.36
	1342.0	1674	405	4.12		1421.0	2322	475	3.36
	1343.0	1678	397	4.42		1422.0	2341	473	3.20
	1344.0	1685	388	4.42		1423.0	2360	472	3.51
	1345.0	1694	381	4.58		1424.0	2381	473	3.51
	1346.0	1701	376	4.58		1425.0	2404	475	3.36
	1347.0	1708	373	4.73	42	1329.0	1640	601	1.83
	1348.0	1714	369	4.88		1330.0	1639	593	3.05
	1349.0	1725	365	4.73		1331.0	1637	586	3.20
	1350.0	1736	364	4.73		1332.0	1634	571	3.20
	1351.0	1748	360	4.58		1333.0	1630	554	3.51
	1352.0	1757	359	4.58		1334.0	1626	534	3.51
	1353.0	1767	361	4.73		1335.0	1623	512	3.66
	1354.0	1782	360	4.58		1336.0	1623	494	3.81
	1355.0	1793	363	4.42		1337.0	1628	477	4.12
	1356.0	1804	371	4.27		1338.0	1643	462	4.27
	1357.0	1818	377	4.27		1340.0	1682	438	4.42
	1358.0	1832	386	4.27		1341.0	1703	429	4.58
	1359.0	1850	395	4.42		1342.0	1714	425	4.88
	1400.0	1872	409	4.27		1343.0	1726	420	4.88
	1401.0	1896	419	4.12		1344.0	1740	414	4.73
	1402.0	1919	435	3.97		1345.0	1751	411	4.88

Appendix D-2

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)
42	1346.0	1767	404	5.03
	1347.0	1781	400	4.73
	1349.0	1797	411	4.58
	1350.0	1814	411	4.73
	1351.0	1832	411	4.58
	1352.0	1852	413	4.42
	1353.0	1876	414	4.42
	1354.0	1903	417	4.12
	1355.0	1939	425	3.97
	1356.0	1964	427	3.97
	1357.0	1990	428	3.81
	1358.0	2019	427	3.81
	1359.0	2045	427	3.66
	1400.0	2069	426	3.66
	1401.0	2087	425	3.97
	1402.0	2109	425	4.12
	1403.0	2132	426	4.12
	1404.0	2153	426	4.27
	1405.0	2174	427	4.42
	1406.0	2189	427	4,42
	1407.0	2210	427	4.58
	1408.0	2231	428	4.42
	1409.0	2247	431	4.27
	1410.0	2272	452	3.97
	1411.0	2287	451	4.12
	1412.0	2303	450	3.66
	1413.0	2320	449	3.81
	1414.0	2343	450	3.66
	1415.0	2373	452	3.81

Appendix D-3

Horizontal Position **(X, Y)** and Depth
by Fish and **Time** During Control **3**

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
53	1636	1647	600	1.98	53	1731	1791	354	3.20
	1637	1651	591	3.20		1732	1801	370	3.20
	1638	1656	582	3.81		1733	1814	383	3.05
	1639	1665	69	4.12		1734	1833	396	3.20
	1640	1675	557	4.12		1735	1852	408	3.36
	1641	1686	550	3.97		1736	1882	417	3.51
	1642	1703	540	3.81		1737	1910	418	3.66
	1643	1722	530	3.51		1738	1947	423	3.20
	1644	1741	522	3.05		1739	1979	421	3.05
	1645	1764	515	3.20		1740	2013	414	2.90
	1646	1788	509	3.20		1741	2050	416	2.90
	1647	1814	504	3.36		1743	2125	434	2.90
	1648	1839	504	3.51		1744	2159	443	3.05
	1649	1857	497	3.81		1745	2188	450	3.05
	1650	1868	481	3.97		1746	2218	455	3.20
	1651	1870	471	4.12		1747	2256	478	3.36
	1652	1870	462	4.12		1748	2284	476	3.20
	1653	1867	453	4.12		1749	2314	474	3.20
	1654	1861	447	4.27		1750	2344	472	3.36
	1655	1856	440	4.12		1751	2373	473	3.36
	1656	1849	436	4.12		1752	2395	474	3.51
	1657	1839	431	3.97	54	1636	1651	597	1.37
	1658	1828	427	3.97		1637	1658	592	1.98
	1659	1816	426	3.81		1638	1666	588	3.81
	1700	1805	424	3.66		1639	1674	581	3.97
	1701	1786	423	3.36		1640	1684	572	4.27
	1702	1772	422	3.51		1641	1694	563	4.12
	1703	1752	422	3.36		1642	1705	556	4.12
	1704	1731	421	3.05		1643	1718	546	3.66
	1705	1712	417	3.20		1644	1723	539	3.81
	1706	1692	407	3.51		1645	1732	526	3.66
	1707	1677	389	3.97		1646	1736	513	3.51
	1708	1667	66	3.81		1647	1740	501	3.05
	1709	1667	338	3.81		1648	1741	482	3.05
	1710	1671	310	3.66		1649	1740	469	2.90
	1729	1789	284	3.05		1650	1737	453	2.75
	1730	1786	331	3.05		1651	1728	435	2.90

Appendix D-3

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
56	1638	1663	546	3.51	56	1729	2189	448	2.75
	1639	1670	539	3.66		1730	2221	455	2.90
	1640	1686	525	3.20		1731	2253	479	2.75
	1642	1733	509	2.90		1732	2287	475	2.90
	1643	1767	503	2.75		1733	2322	476	2.75
	1644	1798	498	2.90		1734	2354	474	2.90
	1645	1637	493	3.51		1735	2384	473	2.75
	1646	1865	488	3.66	58	1636	1652	587	1.07
	1647	1881	477	3.81		1637	1658	572	1.83
	1648	1896	465	3.66		1638	1667	559	2.59
	1649	1902	458	3.81		1639	1676	552	3.20
	1650	1912	453	3.97		1640	1688	541	3.81
	1651	1921	442	3.36		1641	1706	540	3.05
	1652	1929	428	2.90		1642	1730	532	2.90
	1653	1931	396	2.90		1643	1753	530	2.44
	1654	1901	374	2.29		1644	1783	525	2,29
	1655	1850	373	2.14		1645	1808	523	2.90
	1656	1816	368	1.83		1646	1827	517	3.66
	1657	1787	365	2.14		1647	1643	505	3.81
	1658	1767	361	2.29		1648	1851	493	4.12
	1659	1751	356	2.75		1649	1853	482	3.97
	1700	1737	345	2.90		1650	1854	471	3.66
	1701	1729	332	3.20		1651	1854	459	3.20
	1702	1725	297	3.36		1652	1850	445	2.59
	1714	1759	339	2.75		1653	1831	427	2.44
	1715	1768	371	2.75		1654	1810	417	2.59
	1716	1779	385	2.75		1655	1789	408	2.44
	1717	1795	401	2.59		1656	1766	397	2.90
	1718	1820	413	2.44		1657	1745	385	3.05
	1719	1852	423	2.44		1658	1734	370	3.51
	1720	1892	430	2.29		1659	1726	348	3.81
	1721	1940	431	2.29		1700	1719	333	3.66
	1722	1975	429	2.44		1719	1656	368	3.51
	1723	2007	430	2.44		1720	1638	383	3.66
	1724	2037	431	2.59		1721	1639	397	3.97
	1725	2061	431	2.59		1722	1646	408	3.51
	1726	2090	434	2.44		1723	1664	416	2.75
	1727	2121	441	2.59		1724	1693	421	2.75
	1728	2158	443	2.59		1725	1727	417	2.44

Appendix D-3

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
58	1726	1762	416	2.59	59	1659	1764	431	3.97
	1727	1798	412	2.59		1700	1751	422	3.81
	1728	1831	407	2.44		1701	1736	412	3.51
	1729	1867	401	2.59		1702	1722	404	3.36
	1730	1904	399	2.75		1703	1706	390	3.51
	1731	1961	403	2.90		1704	1698	373	3.66
	1732	2016	411	2.75		1705	1674	353	3.81
	1733	2063	421	2.59		1725	1622	313	2.90
	1734	2113	431	2.59		1726	1621	329	2.90
	1735	2168	450	2.44		1727	1621	345	3.05
	1736	2218	476	2.44		1728	1621	358	3.05
	1737	2263	507	2.59		1729	1624	376	3.05
	1738	2309	514	2.75		1730	1628	392	3.20
	1739	2355	520	2.90		1731	1637	409	3.05
	1740	2394	524	2.75		1732	1650	425	3.20
	1741	2428	525	2.90		1733	1669	437	3.05
59	1636	1649	602	1.68		1734	1694	446	2.90
	1637	1654	588	3.36		1735	1716	448	2.75
	1638	1658	583	3.81		1736	1734	450	3.05
	1639	1663	575	3.81		1737	1748	447	3.20
	1640	1670	66	4.12		1738	1766	444	3.51
	1641	1680	558	3.66		1739	1782	438	3.66
	1642	1690	551	3.51		1740	1804	432	3.66
	1643	1703	545	3.51		1741	1828	426	3.81
	1644	1715	539	3.36		1742	1861	419	3.66
	1645	1727	535	3.20		1743	1891	415	3.66
	1646	1738	531	3.36		1744	1931	417	3.51
	1647	1750	525	3.51		1745	1961	415	3.36
	1648	1759	521	3.81		1746	1987	417	3.36
	1649	1767	513	3.97		1747	2015	419	3.51
	1650	1774	506	4.12		1748	2045	422	3.36
	1651	1778	501	4.42		1749	2071	422	3.20
	1652	1781	495	4.42		1750	2112	428	3.05
	1653	1783	487	4.12		1751	2145	434	3.05
	1654	1786	478	4.12		1752	2178	442	3.20
	1655	1787	468	4.27		1753	2212	448	3.51
	1656	1785	457	4.42		1754	2249	471	3.66
	1657	1782	447	4.12		1755	2276	471	3.66
	1658	1773	438	3.97		1756	2304	468	3.66

Appendix D-3

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
59	1757	2331	465	3.51	60	1731	1938	412	2.90
	1758	2357	462	3.51		1732	1977	429	2.90
	1759	2380	459	3.66		1733	2017	450	2.75
	1800	2395	460	3.66		1734	2059	462	2.90
60	1636	1647	593	1.83		1735	2103	465	2.90
	1637	1650	578	2.90		1736	2142	465	3.05
	1638	1655	554	3.51		1737	2169	459	3.36
	1639	1663	540	3.81		1738	2211	459	3.20
	1640	1676	526	3.97		1739	2263	466	2.90
	1641	1702	515	3.66		1740	2299	481	3.05
	1642	1727	512	3.05		1741	2336	476	2.90
	1643	1753	513	2.75		1742	2372	475	2.75
	1644	1778	511	2.90		1743	2399	466	2.90
	1645	1804	504	3.36	61	1636	1644	586	1.07
	1646	1815	494	4.12		1637	1650	548	2.29
	1647	1822	481	3.97		1638	1668	522	3.20
	1648	1822	467	3.81		1639	1673	499	3.36
	1649	1811	449	3.36		1640	1697	482	2.90
	1650	1783	429	3.20		1641	1724	470	2.44
	1651	1744	423	2.90		1642	1764	457	2.59
	1652	1706	418	2.75		1643	1804	447	2.44
	1653	1681	412	2.90		1644	1841	443	2.59
	1654	1658	400	2.90		1645	1882	443	2.59
	1655	1640	374	3.36		1646	1927	443	2,44
	1656	1637	350	3.66		1647	1990	447	2.59
	1657	1638	319	3.81		1648	2050	449	2.59
	1718	1655	323	3.05		1649	2115	451	2.75
	1719	1656	340	3.05		1650	2181	454	2.75
	1720	1657		3.20		1651	2260	465	2.59
	1721	1663	380	3.51	62	1636	1629	611	1.37
	1722	1683	401	3.20		1637	1627	582	1.68
	1723	1702	408	3.05		1638	1619	564	2.90
	1724	1726	410	2.75		1639	1619	557	3.20
	1725	1743	408	2.75		1640	1618	548	4.12
	1726	1781	403	2.90		1641	1618	539	4.12
	1727	1810	397	2.75		1642	1621	534	3.97
	1728	1833	395	2.59		1643	1625	528	3.81
	1729	1863	395	2.44		1644	1630	524	3.66
	1730	1898	398	2.59		1645	1638	520	3.66

Appendix D-3

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
62	1646	1651	516	3.51	62	1737	1626	470	3.97
	1647	1663	513	3.05		1738	1628	474	4.12
	1648	1678	508	2.90		1739	1633	478	3.97
	1649	1691	505	2.75		1740	1636	479	3.81
	1650	1704	500	2.90		1741	1644	481	3.81
	1651	1716	497	2.90		1742	1652	482	3.66
	1652	1730	493	3.05		1743	1665	480	3.51
	1653	1744	488	3.51		1744	1681	474	3.05
	1654	1755	485	3.66		1745	1699	470	2.90
	1655	1758	482	3.81		1746	1719	469	2.75
	1656	1764	480	3.97		1747	1738	470	2.75
	1657	1768	475	3.97		1748	1756	469	2.90
	1658	1771	469	3.81		1749	1778	470	2.75
	1659	1772	462	3.97		1750	1797	468	2.59
	1700	1768	456	3.81		1751	1813	471	2.44
	1701	1765	452	3.81		1752	1834	470	2.59
	1702	1756	447	3.51		1753	1859	470	2.59
	1703	1743	445	3.05		1754	1893	469	2.44
	1704	1727	444	2.90		1755	1925	471	2.44
	1705	1717	441	2.90		1757	1983	465	2.44
	1706	1707	436	2.59		1758	2016		2.59
	1707	1693	429	2.44		1759	2047	451	2.75
	1708	1677	421	2.75		1800	2075	447	2.90
	1709	1665	411	3.20		1801	2110	444	2.90
	1710	1656	99	3.51		1802	2148	448	2.75
	1711	1651	386	3.66		1803	2189	456	2.75
	1712	1648	369	3.81		1804	2225	467	2.90
	1713	1649	357	3.66		1805	2266	490	2.75
	1714	1652	357	3.51		1806	2299	489	2.90
	1726	1634	346	2.90		1807	2337	486	2.90
	1727	1635	361	2.75		1808	2376	486	2.75
	1728	1635	373	2.75		1809	2408	484	2.75
	1729	1636	384	2.59	63	1636	1643		2.14
	1730	1639	400	2.59		1637	1644	571	3.20
	1731	1637	413	2.44		1638	1645	551	3.51
	1732	1635	426	2.90		1639	1645	525	3.66
	1733	1629	441	3.20		1640	1653	514	3.97
	1735	1623	458	3.51		1641	1666	504	4.12
	1736	1623	465	3.81		1642	1668	496	4.27

Appendix D-3

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
63	1643	1677	490	4.27	63	1734	2028	449	3.20
	1644	1687	487	4.12		1735		459	3.36
	1645	1701	482	3.97		1738	2143	465	3.20
	1646	1716	479	3.51		1740	2333	497	3.36
	1647	1732	478	3.05		1746	2418	543	3.51
	1648	1751	476	2.90		1747	2427	525	3.05
	1649	1774	478	3.36	64	1636	1643	596	2.29
	1650	1803	477	3.66		1637	1645	582	2.59
	1651	1817	478	4.12		1638	1650	574	3.51
	1652	1827	477	4.42		1639	1657	563	3.81
	1653	1835	474	4.27		1640	1670	555	3.81
	1654	1841	471	4.27		1641	1687	551	3.36
	1655	1847	465	4.12		1642	1706	548	3.20
	1656	1850	458	3.97		1643	1724	548	2.75
	1657	1852	452	3.66		1644	1741	546	2.75
	1658	1853	444	3.81		1645	1763	546	2.59
	1659	1852	435	3.66		1646	1776	543	2.59
	1700	1848	426	3.81		1647	1789	540	2.75
	1701	1835	414	3.66		1648	1798	535	3.05
	1702	1817	406	3.81		1649	1804	529	3.51
	1703	1795	398	3.81		1650	1809	523	3.66
	1704	1774	390	3.66		1651	1813	518	3.81
	1705	1755	66	3.66		1652	1815	511	3.97
	1706	1743	348	3.51		1653	1815	504	3.66
	1708	1729	328	3.36		1654	1812	496	3.51
	1718	1691	346	2.90		1655	1809	486	3.20
	1720	1704	359	2.75		1656	1799	474	2.75
	1721	1709	371	2.75		1657	1788	467	2.59
	1722	1717	377	2.90		1658	1776	459	2.59
	1723	1724	386	3.05		1659	1764	448	2.44
	1724	1738	393	3.05		1700	1756	436	2.75
	1725	1757		3.20		1701	1750	425	3.20
	1727	1808	402	3.51		1702	1743	408	3.20
	1728	1839	402	3.36		1703	1741	387	3.36
	1729	1877	403	3.36		1704	1737	367	3.05
	1730	1913	407	3.20		1705	1735	350	3.05
	1731	1946	420	3.20		1718	1698	354	2.75
	1732	1975	429	3.05		1719	1689	83	2.75
	1733	2002	441	3.05		1720	1666	396	2.90

Appendix D-3

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
64	1721	1644	400	3.20	67	1652	1763	472	3.36
	1722	1632	407	3.36		1653	1755	457	3.20
	1723	1625	413	3.51		1654	1744	438	2.75
	1724	1623	423	3.66		1655	1735	418	2.75
	1725	1624	430	3.66		1656	1727	394	2.59
	1726	1626	435	3.51		1657	1721	378	3.20
	1727	1628	440	3.36		1658	1718	357	3.05
	1728	1634	446	3.51		1714	1705	353	2.75
	1729	1640	450	3.20		1715	1703	382	2.59
	1730	1649	452	3.05		1716	1709	413	2.59
	1731	1663	458	2.90		1717	1737	432	2.44
	1732	1680	460	2.75		1718	1773	434	2.59
	1733	1702	460	2.90		1719	1810	434	2.75
	1734	1734	460	2.75		1720	1850	431	2.90
	1740	2026	455	2.44		1721	1883	430	2.90
	1741	2049	476	2.59		1722	1927	432	2.90
	1742	2094	472	2.59		1723	1966	432	2.75
	1744	2175	519	2.90		1724	2014	432	2.75
	1745	2248	482	2.90		1725	2060	432	2.90
	1746	2296	472	3.05		1726	2106	437	2.75
	1747	2340	462	3.20		1727	2154	447	2.59
	1748	2375	459	3.05		1728	2195	459	2.59
	1749	2405	459	2.90		1729	2239	487	2.75
67	1636	1645	616	1.22		1730	2279	486	2.90
	1637	1654	594	1.98		1731	2317	484	3.05
	1638	1661	589	3.20		1732	2356	482	3.20
	1639	1670	579	4.12		1733	2389	483	3.05
	1640	1681	574	3.97		1734	2416	485	2.90
	1641	1692	567	3.66	68	1636	1641	594	1.83
	1642	1707	561	3.51		1637	1641	575	2.90
	1643	1723	556	3.05		1638	1640	558	3.81
	1644	1736	552	2.90		1639	1644	536	4.27
	1645	1750	544	2.44		1840	1652	517	4.12
	1646	1758	539	3.20		1641	1660	505	3.97
	1647	1761	530	3.81		1642	1659	497	3.51
	1648	1765	521	3.97		1643	1699	489	3.05
	1649	1767	513	3.97		1644	1723	487	2.75
	1650	1767	504	3.66		1645	1743	488	2.90
	1651	1766	490	3.36		1646	1761	488	3.51

Appendix D-3

Continued

Fish No,	Time	x (m)	Y (m)	Depth (m)	Fish No.	Time	x (m)	Y (m)	Depth (m)
68	1647	1773	485	4.12	68	1740	1646	480	3.05
	1648	1780	488	4.27		1741	1669	474	2.75
	1649	1788	486	4.42		1742	1699	469	2.90
	1650	1796	485	3.97		1743	1732	468	2.90
	1651	1803	480	4.12		1745	1787	469	2.75
	1652	1807	470	3.97		1746	1819	469	2.59
	1653	1801	463	3.81		1747	1843	470	2.44
	1654	1786	459	3.51		1748	1872	466	2.59
	1655	1762	465	3.05		1749	1906	461	2.59
	1656	1736	448	3.20		1750	1946	467	2.75
	1657	1723	436	2.90		1751	1978	472	2.75
	1658	1710	413	3.05		1752	2010	479	2.90
	1659	1704	390	3.36		1753	2047	488	2.75
	1700	1700	365	3.51		1759	2257	527	3.36
	1702	1680	352	3.81		1800	2286	517	3.20
	1716	1614	316	2.44		1801	2316	500	3.20
	1717	1617	330	2.44		1802	2338	487	3.51
	1718	1607	303	2.90		1803	2357	474	3.36
	1719	1619	365	3.05		1804	2383	460	3.51
	1720	1622	391	3.05		1805	2405	449	3.20
	1721	1620	414	3.51	69	1636	1639	600	2.29
	1722	1613	439	3.81		1637	1637	586	3.20
	1723	1608	449	4.12		1638	1637	576	3.66
	1724	1605	456	4.27		1639	1635	566	3.97
	1725	1601	464	4.42		1640	1640	552	4.12
	1726	1597	469	4.27		1641	1644	543	3.97
	1727	1594	474	4.27		1642	1649	539	3.81
	1728	1592	481	4.12		1643	1655	534	3.51
	1729	1588	486	4.27		1644	1663	534	3.05
	1730	1585	492	4.12		1645	1669	529	3.05
	1731	1582	499	3.97		1646	1676	529	3.20
	1732	1580	508	3.66		1647	1684	527	3.05
	1733	1582	516	3.51		1648	1690	525	2.90
	1734	1588	522	3.20		1649	1700	523	2.90
	1735	1593	524	3.20		1650	1712	519	2.90
	1736	1603	524	3.36		1651	1717	517	2.75
	1737	1615	516	3.51		1652	1723	512	2.75
	1738	1625	501	3.51		1653	1729	508	2.90
	1739	1634	490	3.20		1654	1737	501	3.05

Appendix D-3

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
69	1655	1742	493	3.05	69	1757	2152	484	3.51
	1656	1746	488	3.20		1758	2190	503	3.51
	1657	1750	479	3.05		1759	2226	528	3.66
	1658	1754	468	3.20		1800	2257	522	3.81
	1659	1755	455	3.05		1801	2286	515	3.81
	1700	1754	441	3.36		1802	2313	511	3.66
	1701	1750	430	3.51		1803	2341	506	3.51
	1702	1744	418	3.66		1804	2365	506	3.51
	1704	1732	393	4.12		1805	2391	504	3.36
	1705	1726	382	4.12	70	1636	1631	592	2.29
	1706	1722	362	3.81		1637	1626	576	2.59
	1707	1717	350	3.66		1638	1623	562	3.51
	1708	1717	350	3.51		1639	1621	545	3.66
	1730	1688	353	2.90		1640	1615	519	3.66
	1731	1689	353	2.90		1641	1610	504	3.81
	1732	1702	341	3.05		1642	1606	494	3.97
	1733	1700	365	3.05		1643	1602	485	4.12
	1734	1701	379	3.20		1644	1600	477	4.12
	1735	1703	396	3.05		1645	1599	467	4.27
	1736	1706	411	3.05		1646	1602	460	4.42
	1737	1707	427	2.90		1647	1607	455	4.42
	1738	1710	444	2.90		1648	1613	451	4.27
	1739	1721	461	2.75		1649	1620	449	4.12
	1740	1731	471	2.75		1650	1631	447	3.97
	1741	1747	475	2.90		1651	1646	447	3.66
	1742	1764	478	2.90		1652	1662	448	3.66
	1743	1781	479	3.05		1653	1678	446	3.81
	1744	1804	473	3.05		1654	1701	450	3.66
	1745	1825	468	3.20		1655	1728	452	3.51
	1746	1848	462	3.20		1656	1751	458	3.36
	1747	1876	457	3.36		1657	1770	464	3.51
	1748	1902	453	3.36		1658	1779	465	3.66
	1749	1932	452	3.51		1659	1787	464	3.81
	1750	1865	452	3.36		1700	1793	462	3.97
	1751	1997	456	3.51		1701	1799	457	3.97
	1752	2023	460	3.36		1702	1802	450	4.12
	1753	2050	468	3.36		1703	1800	443	4.27
	1755	2097	481	3.66		1704	1784	437	4.27
	1756	2122	489	3.66		1705	1781	424	4.12

Appendix D-3

Continued

Fish No.	Time	X (m)	‘f (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
70	1706	1766	412	3.97	71	1641	1647	548	3.81
	1707	1748	400	3.66		1642	1651	537	3.36
	1708	1730	391	3.51		1643	1655	527	3.36
	1709	1718	370	3.66		1644	1658	518	3.20
	1710	1714	346	3.81		1645	1668	513	2.90
	1727	1647	315	3.05		1646	1678	507	2.75
	1728	1647	339	3.05		1647	1687	504	2.75
	1729	1646	361	3.20		1648	1701	498	2.59
	1730	1652	384	3.05		1649	1713	496	2.90
	1731	1662	404	3.20		1650	1723	488	3.36
	1732	1673	414	3.36		1651	1728	483	3.81
	1733	1672	411	3.36		1652	1730	479	3.97
	1734	1700	429	3.20		1653	1731	472	4.12
	1735	1720	435	3.36		1654	1729	466	3.97
	1736	1739	443	3.36		1655	1726	462	3.81
	1737	1760	443	3.36		1656	1721	456	3.51
	1738	1784	446	3.36		1657	1715	452	3.05
	1739	1817	448	3.20		1658	1703	445	3.05
	1740	1848	451	3.05		1659	1688	440	2.90
	1741	1879	452	3.05		1700	1667	431	2.75
	1742	1908	458	3.20		1701	1652	415	2.90
	1743	1936	465	3.20		1702	1651	396	3.20
	1744	1969	475	3.05		1703	1649	374	3.20
	1745	2001	485	2.90		1704	1648	358	3.36
	1746	2036	491	2.90		1705	1649	341	3.51
	1748	2098	499	2.90		1717	1631	337	2.75
	1749	2139	497	3.05		1718	1634	359	2.44
	1750	2178	501	3.36		1719	1632	375	2.59
	1751	2207	519	3.51		1720	1634	393	2.44
	1752	2245	516	3.36		1721	1636	412	2.59
	1753	2284	512	3.20		1722	1639	432	2.90
	1754	2321	509	3.20		1723	1646	450	3.05
	1755	2348	510	3.05		1724	1656	472	3.51
	1756	2383	510	3.20		1725	1679	491	3.66
71	1636	1640	600	1.98		1726	1706	509	3.81
	1637	1640	588	3.05		1729	1794	483	2.90
	1638	1640	579	3.81		1730	1823	467	2.90
	1639	1641	569	3.97		1731	1852	452	2.75
	1640	1643	557	4.12		1732	1894	444	2.90

Appendix D-3

Continued

Fish No.	Time	x (m)	Y [m]	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
71	1733	1949	443	2.90	72	1707	1719	425	3.05
	1734	2014	445	2.90		1708	1704	416	3.20
	1735	2078	446	2.75		1709	1688	407	3.36
	1736	2140	452	2.59		1710	1669	393	3.81
	1737	2210	454	2.59		1711	1654	376	3.97
	1738	2279	464	2.44		1712	1648	358	3.81
	1740	2380	446	2.90		1713	1647	331	3.66
	1741	2413	444	2.90		1714	1647	315	3.81
72	1636	1634	595	2.75		1715	1645	288	3.66
	1637	1630	585	3.66		1741	1663	307	2.75
	1638	1625	575	3.81		1742	1668	309	2.75
	1639	1620	562	3.97		1743	1664	334	2.75
	1640	1618	548	4.12		1744	1660	351	2.59
	1641	1621	539	4.42		1745	1656	362	2.75
	1642	1623	530	4.58		1746	1650	378	2.90
	1643	1629	523	4.27		1747	1639	390	3.20
	1644	1635	516	4.12		1748	1625	397	3.36
	1645	1640	512	3.81		1749	1609	406	3.05
	1646	1652	508	3.66		1750	1595	411	2.90
	1647	1659	505	3.36		1751	1589	417	2.90
	1648	1672	504	3.36		1752	1586	421	2.75
	1649	1684	502	3.20		1753	1585	426	2.75
	1650	1694	501	3.05		1754	1584	432	2.75
	1651	1706	503	3.36		1755	1586	437	2.90
	1652	1720	504	3.51		1756	1587	441	3.05
	1653	1733	504	3.81		1757	1590	446	3.20
	1654	1745	502	3.97		1758	1598	454	3.05
	1655	1752	501	4.12		1759	1598	454	3.05
	1656	1756	498	4.42		1800	1604	458	3.20
	1657	1763	494	4.27		1801	1608	459	3.51
	1658	1768	489	4.42		1802	1622	463	3.66
	1659	1771	484	4.12		1803	1632	465	3.81
	1700	1773	476	4.12		1804	1644	464	3.66
	1701	1772	468	4.12		1805	1659	459	3.36
	1702	1769	464	4.27		1806	1675	453	3.51
	1703	1765	457	4.12		1807	1691	447	3.36
	1704	1758	450	3.97		1808	1705	441	3.36
	1705	1746	440	3.81		1809	1720	436	3.51
	1706	1734	434	3.51		1810	1733	430	3.66

Appendix D-3

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Fish No.	Time	X (m)	Y (m)	Depth (m)
54	1652	1721	418	2.90	55	1638	1673	556	3.97
	1653	1712	399	3.36		1639	1691	540	4.12
	1654	1704	383	3.81		1640	1709	530	3.66
	1655	1698	363	3.97		1641	1727	526	3.51
	1725	1625	347	3.05		1642	1748	525	3.05
	1726	1624	365	3.20		1643	1770	524	2.90
	1727	623	383	3.51		1644	792	520	2.90
	1728	621	401	3.81		1645	808	523	3.20
	1729	621	416	3.81		1646	830	508	3.36
	1730	623	427	3.97		1647	843	491	3.81
	1731	626	434	4.12		1648	848	480	3.97
	1732	1634	442	4.12		1649	1850	472	4.12
	1733	1645	448	3.97		1650	1853	460	4.27
	1734	1659	453	3.66		1651	1854	450	3.97
	1735	1682	452	3.81		1652	1853	439	3.81
	1736	1709	452	3.51		1653	1843	424	3.36
	1737	1733	452	3.36		1854	826	412	3.05
	1738	1756	454	2.90		1655	800	404	2.90
	1739	1783	452	2.90		1656	773	405	2.75
	1740	1814	452	2.75		1657	747	399	2.75
	1741	1845	460	2.90		1658	723	386	2.90
	1742	1886	455	3.05		1714	1625	274	3.05
	1743	1923	447	3.20		1715	1627	348	3.51
	1744	1957	439	3.05		1716	1629	379	3.05
	1745	1994	435	2.90		1717	1643	416	3.20
	1746	2029	433	2.90		1718	1683	442	3.05
	1747	2073	431	2.75		1719	1734	453	2.90
	1748	2098	447	2.75		1720	1784	452	2.75
	1749	2141	440	2.75		1721	1840	452	2.75
	1750	2182	433	2.75		1722	1903	452	2.90
	1751	2226	428	2.75		1723	1975	464	2.75
	1752	2260	435	2.75		1724	2043	476	2.59
	1753	2289	439	2.75		1728	2271	509	2.90
	1754	2318	441	2.75		1729	2307	503	2.90
	1755	2352	456	2.90		1730	2340	495	2.75
	1756	2374	455	3.05		1731	2366	488	2.90
	1757	2399	452	2.90		1732	2393	484	3.20
55	1636	1655	85	2.14	56	1636	1650	586	1.37
	1637	1663	571	3.81		1637	1657	558	2.44

Appendix D-3

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)
72	1811	1745	428	3.51
	1812	1760	425	3.36
	1814	1799	415	3.05
	1815	1814	413	3.05
	1816	1835	410	3.20
	1817	1851	406	3.05
	1818	1869	403	3.05
	1820	1911	403	2.90
	1821	1937	412	2.75
	1822	1963	413	2.59
	1823	1990	416	2.59
	1824	2021	423	2.75
	1825	2054	429	2.90
	1826	2088	438	2.75
	1827	2121	449	2.90
	1828	2152	457	2.90
	1829	2181	465	2.90
	1830	2208	469	2.75
	1831	2240	497	2.90
	1832	2270	496	3.05
	1833	2299	501	3.20
	1834	2329	495	3.36
	1835	2359	494	3.36
	1836	2381	495	3.51
	1837	2403	494	3.36

Appendix D-4

Horizontal Position (X, Y) and Depth
by Fish and Time During Treatment 1

Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)
13	2213.0	1645	606	0.46	< 1.00E-01	14	2326.0	1658	402	3.97	< 1.00E-01
	2214.0	1648	595	1.83	< 1.00E-01		2327.0	1670	393	3.81	< 1.00E-01
	2215.0	1651	583	2.75	< 1.00E-01		2328.0	1685	383	3.81	< 1.00E-01
	2216.0	1653	567	3.20	1.38E-01		2329.0	1704	374	3.66	< 1.00E-01
	2217.0	1655	548	3.20	4.53E-01		2330.0	1728	367	3.66	< 1.00E-01
	2218.0	1655	531	3.51	4.48E-01		2331.0	1761	372	3.51	< 1.00E-01
	2219.0	1655	511	3.36	8.76E-01		2332.0	1794	382	3.51	< 1.00E-01
	2220.0	1659	500	3.51	4.01 E-01		2343.0	2077	387	3.36	< 1.00E-01
	2221.0	1660	489	3.66	1.68E-01		2344.0	2089	383	3.51	< 1.00E-01
	2222.0	1660	481	3.81	< 1.00E-01		2345.0	2103	379	3.51	< 1.00E-01
	2223.0	1658	472	3.97	< 1.00E-01		2346.0	2115	374	3.51	< 1.00E-01
	2224.0	1649	458	4.42	< 1.00E-01		2347.0	2125	371	3.66	< 1.00E-01
	2225.0	1641	444	4.73	< 1.00E-01		2348.0	2138	366	3.66	< 1.00E-01
	2226.0	1636	434	4.42	c 1.00E-01		2349.0	2150	358	3.51	c 1.00E-01
	2227.0	1635	422	4.27	< 1.00E-01		2350.0	2163	355	3.36	< 1.00E-01
	2228.0	1638	410	4.42	< 1.00E-01		2351.0	2174	350	3.36	c 1.00E-01
	2229.0	1645	394	4.42	< 1.00E-01		2352.0	2189	343	3.51	c 1.00E-01
	2230.0	1651	374	4.42	< 1.00E-01		2353.0	2201	339	3.66	< 1.00E-01
14	2214.0	1641	595	1.37	< 1.00E-01		2354.0	2212	334	3.81	< 1.00E-01
	2215.0	1638	586	1.98	< 1.00E-01		2355.0	2225	330	3.97	< 1.00E-01
	2216.0	1637	573	2.90	1.36E-01		2356.0	2234	326	3.97	< 1.00E-01
	2217.0	1630	554	3.97	1.96E-01		2357.0	2242	324	3.81	< 1.00E-01
	2218.0	1626	540	4.12	5.22E-01	15	2214.0	1639	582	2.14	< 1.00E-01
	2219.0	1616	523	4.42	5.01 E-01		2215.0	1628	555	3.20	1.45E-01
	2220.0	1609	508	4.58	2.65E-01		2216.0	1591	539	3.81	1.69E-01
	2221.0	1599	494	4.73	< 1.00E-01		2217.0	1538	529	4.12	1.09E-01
	2222.0	1592	485	4.73	4.64E-01		2218.0	1509	520	4.27	< 1.00E-01
	2317.0	1580	472	5.03	4.73E-01		2220.0	1533	472	4.58	< 1.00E-01
	2318.0	1566	466	4.73	3.24E-01		2221.0	1610	456	4.27	< 1.00E-01
	2319.0	1547	459	4.58	1.05E-01		2222.0	1677	402	4.42	< 1.00E-01
	2320.0	1541	443	4.58	1.28E-01		2223.0	1779	368	3.97	< 1.00E-01
	2321.0	1547	434	4.42	< 1.00E-01		2225.0	1993	403	3.51	< 1.00E-01
	2322.0	1565	428	4.42	1.17E-01		2226.0	2095	386	3.51	< 1.00E-01
	2323.0	1590	427	4.27	< 1.00E-01	16	2214.0	1645	598	1.83	< 1.00E-01
	2324.0	1621	424	3.97	< 1.00E-01		2215.0	1648	584	2.59	< 1.00E-01
	2325.0	1643	414	4.12	< 1.00E-01		2216.0	1648	564	3.20	1.48E-01

Appendix D-4

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)
16	2217.0	1648	546	3.36	4.45E-01	18	2235.0	2034	381	3.66	< 1.00E-01
	2218.0	1643	529	3.36	3.54E-01		2236.0	2083	374	3.51	< 1.00E-01
	2219.0	1638	507	3.51	< 1.00E-01		2237.0	2136	364	3.36	< 1.00E-01
	2220.0	1632	479	3.81	< 1.00E-01	19	2214.0	1646	599	2.14	< 1.00E-01
	2222.0	1623	432	4.27	< 1.00E-01		2215.0	1650	590	2.90	< 1.00E-01
	2223.0	1622	405	4.42	< 1.00E-01		2216.0	1657	575	3.36	1.40E-01
	2224.0	1626	382	3.97	c 1.00E-01		2217.0	1664	561	3.51	3.63E-01
	2225.0	1634	359	3.66	< 1.00E-01		2218.0	1675	540	3.51	9.48E-01
17	2214.0	1644	591	2.29	< 1.00E-01		2219.0	1679	519	3.81	5.84E-01
	2215.0	1645	582	3.36	< 1.00E-01		2220.0	1672	499	3.97	1.85E-01
	2216.0	1645	568	3.20	1.53E-01		2221.0	1664	485	4.12	1.41E-01
	2217.0	1643	555	3.51	2.12E-01		2222.0	1660	477	4.42	< 1.00E-01
	2218.0	1640	542	3.36	4.04E-01		2223.0	1655	469	4.42	c 1.00E-01
	2219.0	1638	530	3.51	4.98E-01		2224.0	1656	459	4.58	< 1.00E-01
	2220.0	1636	517	3.66	4.05E-01		2225.0	1659	451	4.73	< 1.00E-01
	2221.0	1630	502	3.81	1.24E-01		2226.0	1664	443	4.27	< 1.00E-01
	2222.0	1624	485	4.12	< 1.00E-01		2227.0	1674	435	4.12	< 1.00E-01
	2223.0	1617	464	4.42	< 1.00E-01		2228.0	1686	424	3.97	< 1.00E-01
	2224.0	1613	440	4.42	< 1.00E-01		2229.0	1698	413	3,66	< 1.00E-01
	2225.0	1613	419	4.27	< 1.00E-01		2230.0	1707	393	3.66	c 1.00E-01
	2226.0	1613	398	3.97	< 1.00E-01		2231.0	1709	371	3.81	< 1.00E-01
	2227.0	1617	379	4.12	< 1.00E-01		2232.0	1709	371	3.66	< 1.00E-01
	2228.0	1622	364	3.66	< 1.00E-01	20	2214.0	1638	591	2.59	< 1.00E-01
18	2214.0	1647	593	1.68	< 1.00E-01		2215.0	1625	568	3.o5	< 1.00E-01
	2215.0	1648	580	2.59	< 1.00E-01		2216.0	1582	545	3.51	< 1.00E-01
	2216.0	1648	567	2.90	< 1.00E-01		2217.0	1541	536	3.97	1.83E-01
	2217.0	1639	547	3.36	4.82E-01		2219.0	1495	508	4.42	< 1.00E-01
	2218.0	1624	525	3.51	5.65E-01		2220.0	1527	487	4.58	< 1.00E-01
	2219.0	1613	503	3.81	< 1.00E-01		2221.0	1603	470	4.27	< 1.00E-01
	2220.0	1611	481	3.97	< 1.00E-01		2225.0	1982	415	3.66	c 1.00E-01
	2221.0	1612	458	4.27	< 1.00E-01		2226.0	2094	401	3.66	< 1.00E-01
	2222.0	1616	435	4.42	< 1.00E-01	21	2214.0	1644	597	1,53	< 1.00E-01
	2227.0	1714	360	4.27	< 1.00E-01		2215.0	1645	578	2.59	1.59E-01
	2228.0	1750	356	4.12	c 1.00E-01		2216.0	1846	551	3.20	4.02E-01
	2229.0	1783	360	3.97	< 1.00E-01		2217.0	1643	529	3.51	2.89E-01
	2230.0	1821	364	3.97	< 1.00E-01		2218.0	1636	507	3.81	1.08E-01
	2231.0	1863	374	3,81	c 1.00E-01		2219.0	1628	489	3.97	c 1.00E-01

Appendix D-4

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)
21	2220.0	1626	478	4.42<	1.00E-01
	2221.0	1625	467	4.27<	1.00E-01
	2222.0	1626	458	4.27<	1.00E-01
	2223.0	1627	447	4.12<	1.00E-01
	2224.0	1633	437	3.97<	1.00E-01
	2225.0	1638	424	3.66<	1.00E-01
	2226.0	1644	409	3.66<	1.00E-01
	2227.0	1653	392	3.81 <	1.00E-01
	2228.0	1656	372	3.66<	1.00E-01
22	2214.0	1640	610	1.83<	1.00E-01
	2215.0	1642	589	2.59<	1.00E-01
	2216.0	1642	573	3.20	1.38E-01
	2217.0	1642	556	3.36	2.79E-01
	2218.0	1637	538	3.66	2.99E-01
	2219.0	1628	519	4.12	5.72E-01
	2220.0	1614	506	4.27	2.79E-01
	2221.0	1602	496	4.42<	1.00E-01
	2222.0	1593	486	4.27<	1.00E-01
	2223.0	1586	472	4.42<	1.00E-01
	2224.0	1585	464	4.27<	1.00E-01
	2225.0	1586	453	4.12<	1.00E-01
	2226.0	1591	442	3.97<	1.00E-01
	2227.0	1601	434	3.66 <	1.00E-01
	2228.0	1615	425	3.66<	1.00E-01
	2229.0	1625	415	3.81 c	1.00E-01
	2230.0	1638	388	3.66 <	1.00E-01
	2231.0	1645	362	3.51 <	1.00E-01

Appendix D-5

Horizontal Position (X, Y) and Depth by Fish and Time During Treatment 2

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y	Depth (m)	Conc (ppb)
43	1459.0	1642	613	0.46	< 1.00E-01	45	1505.0	1617	463	1.83	< 1.00E-01
	1500.0	1653	598	1.37	< 1.00E-01		1506.0	1633	428	1.98	< 1.00E-01
	1501.0	1658	592	1.83	< 1.00E-01		1507.0	1616	369	2.29	< 1.00E-01
	1502.0	1661	577	2.14	< 1.00E-01		1508.0	1653	356	2.75	< 1.00E-01
	1503.0	1662	560	2.29	< 1.00E-01	46	1500.0	1643	590	1.68	< 1.00E-01
	1504.0	1656	538	2.29	1.93E-01		1501.0	1639	578	1.68	< 1.00E-01
	1505.0	1639	516	2.44	1.60E-01		1502.0	1632	562	1.83	< 1.00E-01
	1506.0	1621	493	2.75	< 1.00E-01		1503.0	1616	542	1.83	< 1.00E-01
	1507.0	1607	471	2.59	c 1.00E-01		1504.0	1598	518	1.68	< 1.00E-01
	1508.0	1596	439	2.59	< 1.00E-01		1505.0	1591	490	1.83	< 1.00E-01
	1509.0	1597	414	2.75	< 1.00E-01		1506.0	1601	465	2.14	< 1.00E-01
	1510.0	1598	384	2.75	< 1.00E-01		1507.0	1617	438	2.29	< 1.00E-01
44	1500.0	1652	583	1.53	< 1.00E-01		1508.0	1630	408	2.29	< 1.00E-01
	1501.0	1652	569	1.68	< 1.00E-01		1509.0	1632	380	2.44	< 1.00E-01
	1502.0	1648	554	1.68	< 1.00E-01	47	1500.0	1634	582	1.37	< 1.00E-01
	1503.0	1641	531	1.83	c 1.00E-01		1501.0	1623	562	1.68	< 1.00E-01
	1504.0	1634	510	2.14	c 1.00E-01		1502.0	1604	536	1.98	< 1.00E-01
	1505.0	1626	487	2.29	< 1.00E-01		1503.0	1577	510	2.14	< 1.00E-01
	1506.0	1619	482	2.29	< 1.00E-01		1504.0	1562	486	2.14	< 1.00E-01
	1507.0	1630	444	2.14	< 1.00E-01		1505.0	1560	470	1.98	< 1.00E-01
	1508.0	1646	420	2.14	< 1.00E-01		1506.0	1562	452	2.14	< 1.00E-01
	1509.0	1676	398	2.44	< 1.00E-01		1507.0	1576	439	2.29	c 1.00E-01
	1510.0	1719	382	2.29	c 1.00E-01		1508.0	1611	431	2.14	< 1.00E-01
	1511.0	1778	378	2.29	< 1.00E-01		1509.0	1675	423	2.29	c 1.00E-01
	1512.0	1833	387	2.44	< 1.00E-01		1510.()	1746	397	2.44	< 1.00E-01
	1513.0	1891	387	2.59	< 1.00E-01		1511.0	1838	395	2.44	< 1.00E-01
	1514.0	1964	383	2.75	< 1.00E-01		1512.0	1935	396	2.59	< 1.00E-01
	1515.0	2031	363	2.90	< 1.00E-01		1514.0	2132	315	2.75	< 1.00E-01
	1516.0	2100	347	2.90	< 1.00E-01	48	1500.0	1652	605	1.98	< 1.00E-01
	1517.0	2180	330	2.75	< 1.00E-01		1501.0	1660	588	1.98	< 1.00E-01
	1518.0	2248	323	2.90	< 1.00E-01		1502.0	1666	576	2.44	< 1.00E-01
45	1500.0	1646	588	1.22	< 1.00E-01		1503.0	1672	566	2.29	< 1.00E-01
	1501.0	1646	575	1.37	< 1.00E-01		1504.0	1676	557	2.14	< 1.00E-01
	1502.0	1637	550	1.53	< 1.00E-01		1505.0	1678	545	2.29	2.02E-01
	1503.0	1625	526	1.68	1.31 E-01		1506.0	1679	531	2.14	5.90E-01
	1504.0	1617	498	1.53	c 1.00E-01		1507.0	1679	514	1.98	5.86E-01

Appendix D-5

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
48	1508.0	1681	497	2.14	< 1.00E-01
	1509.0	1657	471	2.14	< 1.00E-01
	1510.0	1665	467	2.29	< 1.00E-01
	1511.0	1653	455	2.44	< 1.00E-01
	1512.0	1636	448	2.44	< 1.00E-01
	1513.0	1621	445	2.59	< 1.00E-01
	1514.0	1606	446	2.75	< 1.00E-01
	1515.0	1588	453	2.90	< 1.00E-01
	1516.0	1564	464	2.90	c 1.00E-01
	1517.0	1534	474	3.o5	< 1.00E-01
	1518.0	1506	480	3.20	< 1.00E-01
	1519.0	1473	488	3.o5	c 1.00E-01
49	1500.0	1651	597	1.83	< 1.00E-01
	1501.0	1656	586	1.68	< 1.00E-01
	1502.0	1660	573	1.68	< 1.00E-01
	1503.0	1662	562	1.53	< 1.00E-01
	1504.0	1662	544	1.68	1.51E-01
	1505.0	1661	530	1.83	2.54E-01
	1506.0	1653	511	1.98	2.22E-01
	1507.0	1646	497	2.14	< 1.00E-01
	1508.0	1634	476	1.98	< 1.00E-01
	1509.0	1622	455	2.14	< 1.00E-01
	1510.0	1615	438	2.29	< 1.00E-01
	1511.0	1604	416	2.44	< 1.00E-01
	1512.0	1599	395	2.75	< 1.00E-01
	1513.0	1598	373	2.75	< 1.00E-01
	1514.0	1599	352	2.90	< 1.00E-01
	1524.0	1767	389	3.05	< 1.00E-01
	1525.0	1787	417	2.59	< 1.00E-01
	1526.0	1821	430	2.59	< 1.00E-01
	1527.0	1852	427	2.44	< 1.00E-01
50	1500.0	1645	598	1.53	< 1.00E-01
	1501.0	1649	585	1.68	< 1.00E-01
	1502.0	1652	569	1.83	< 1.00E-01
	1503.0	1656	550	1.83	1.07E-01
	1504.0	1653	531	2.14	1.46E-01
	1505.0	1638	509	1.98	1.51 E-01
50	1506.0	1616	494	2.14	c 1.00E-01
	1507.0	1600	478	2.44	c 1.00E-01
	1508.0	1587	460	2.59	c 1.00E-01
	1509.0	1578	438	2.59	< 1.00E-01
	1510.0	1585	413	2.75	< 1.00E-01
	1511.0	1608	396	2.59	< 1.00E-01
	1512.0	1634	392	2.44	< 1.00E-01
	1513.0	1666	391	2.59	< 1.00E-01
	1514.0	1701	387	2.75	< 1.00E-01
	1515.0	1743	389	2.59	< 1.00E-01
	1516.0	1790	398	2.90	< 1.00E-01
	1517.0	1850	397	3.05	c 1.00E-01
	1518.0	1929	389	3.20	< 1.00E-01
	1519.0	1989	362	3.05	< 1.00E-01
	1520.0	1989	362	3.20	c 1.00E-01
	1521.0	2129	329	3.05	< 1.00E-01
	1522.0	2202	323	2.75	< 1.00E-01
	1523.0	2268	329	2.75	< 1.00E-01
	1524.0	2325	396	2.59	c 1.00E-01
51	1500.0	1642	595	1.83	< 1.00E-01
	1501.0	1642	585	1.68	< 1.00E-01
	1502.0	1644	577	1.68	< 1.00E-01
	1503.0	1645	562	1.83	< 1.00E-01
	1504.0	1642	546	1.98	< 1.00E-01
	1505.0	1640	534	2.14	1.50E-01
	1506.0	1636	519	2.14	2.41 E-01
	1507.0	1631	501	2.14	c 1.00E-01
	1508,0	1620	482	1.98	< 1.00E-01
	1510.0	1611	439	2.29	< 1.00E-01
	1511.0	1612	418	2.44	< 1.00E-01
	1512.0	1614	399	2.59	< 1.00E-01
	1513.0	1620	377	2.75	< 1.00E-01
	1514.0	1624	357	2.90	< 1.00E-01
52	1500.0	1637	598	1.98	< 1.00E-01
	1501.0	1634	594	1.68	< 1.00E-01
	1502.0	1630	579	1.83	< 1.00E-01
	1503.0	1626	572	1.98	< 1.00E-01

Appendix D-5

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
52	1504.0	1623	567	1.98	< 1.00E-01
	1505.0	1615	553	2.14	c 1.00E-01
	1506.0	1611	543	2.14	< 1.00E-01
	1507.0	1604	529	2.29	< 1.00E-01
	1508.0	1600	523	2.44	1.49E-01
	1509.0	1591	507	2.59	1.23E-01
	1510.0	1584	499	2.75	1.20E-01
	1511.0	1576	492	2.90	< 1.00E-01
	1513.0	1566	474	3.05	< 1.00E-01
	1514.0	1569	464	3.20	< 1.00E-01
	1515.0	1572	457	3.20	< 1.00E-01
	1516.0	1576	448	3.05	c 1.00E-01
	1517.0	1585	437	3.20	< 1.00E-01
	1518.0	1596	432	2.90	< 1.00E-01
	1519.0	1606	427	2.59	< 1.00E-01
	1520.0	1617	424	2.44	< 1.00E-01
	1521.0	1634	421	2.59	< 1.00E-01
	1522.0	1654	419	2.44	< 1.00E-01
	1523.0	1678	418	2.59	< 1.00E-01
	1524.0	1704	418	2.44	c 1.00E-01
	1525.0	1729	421	2.59	< 1.00E-01
	1526.0	1759	421	2.44	< 1.00E-01
	1527.0	1790	420	2.44	< 1.00E-01
	1528.0	1822	419	2.44	< 1.00E-01

Appendix D-6

Horizontal **Position (X, Y) and Depth**
by Fish and Time During Treatment 3

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)
73	1733.5	1641	612	0.61	c 1.00E-01	73	1849.0	1668	533	3.20	8.50E+00
	1734.0	1643	603	0.61	< 1.00E-01		1850.0	1674	531	3.05	1.01E+01
	1735.0	1644	562	2.90	< 1.00E-01		1851.0	1683	524	3.20	7.06E +00
	1736.0	1656	475	3.66	< 1.00E-01		1852.0	1691	512	3.36	6.76E+00
	1737.0	1664	443	3.97	< 1.00E-01		1853.0	1684	495	3.51	5.25E+00
	1738.0	1668	424	5.19	< 1.00E-01		1854.0	1670	489	3.51	5.19E+00
	1739.0	1672	415	5.03	< 1.00E-01		1855.0	1644	481	3.66	1.31 E+00
	1740.0	1673	407	4.58	< 1.00E-01		1856,0	1607	475	3.97	8.47E-01
	1745.0	1680	390	3.97	c 1.00E-01		1857.0	1568	473	4.27	3.44E-01
	1750.0	1683	379	3.05	< 1.00E-01		1858.0	1535	478	4.42	2.01 E+00
	1755.0	1693	367	2.59	< 1.00E-01		1859.0	1503	481	4.27	5.07E-01
	1800.0	1700	365	2.75	< 1.00E-01		1900.0	1469	490	4.58	2.43E+00
	1805.0	1713	367	3.66	< 1.00E-01		1901.0	1428	498	4.42	2.04E+ 00
	1810.0	1724	378	4.88	c 1.00E-01		1902.0	1371	504	4.27	2.74E +00
	1815.0	1728	396	4.27	< 1.00E-01		1914.5	1350	484	3.81	3.02E-01
	1820.0	1725	417	4.42	< 1.00E-01		1916.0	1422	483	3.97	5.91 E-01
	1825.0	1696	437	4.58	4.39E-01		1917.5	1503	485	4.12	2.28E-01
	1830.0	1646	432	4.27	1.76E-01		1919.0	1576	479	3.97	1.03E +00
	1831.0	1636	430	4.27	1.29E-01		1920.5	1609	436	4.27	1.49E-01
	1832.0	1623	428	4.42	3.26E-01		1922.0	1694	459	4.12	5.09E-01
	1833.0	1610	428	4.58	2.83E-01		1923.5	1770	426	4.27	2.06E-01
	1834.0	1598	429	4.58	2.40E-01		1925.0	1845	404	4.27	< 1.00E-01
	1835.0	1586	435	4.73	1.84E-01		1926.5	1935	396	4.12	< 1.00E-01
	1836.0	1577	445	4.73	1.20E-01		1928.0	2027	378	4.88	< 1.00E-01
	1837.0	1572	466	4.73	9.09E-01		1929.5	2094	371	4.73	c 1.00E-01
	1838.0	1565	465	4.88	1.40E-01		1931.0	2171	370	4.58	< 1.00E-01
	1839.0	1565	480	4.88	1.27E+00		1932.5	2232	382	4.27	< 1.00E-01
	1840.0	1570	491	5.03	3.55E+00		1934.0	2285	414	4.42	< 1.00E-01
	1841.0	1576	501	5.03	8.62E+00		1935.5	2338	415	4.27	c 1.00E-01
	1842.0	1586	509	4.88	6.1 8E+ 00	74	1734.0	1643	613	0.61	< 1.00E-01
	1843.0	1598	517	4.42	1.15E+01		1735.0	1642	585	1.53	< 1.00E-01
	1844.0	1608	522	4,27	9.95E+00		1736.0	1640	566	1.98	< 1.00E-01
	1845.0	1616	526	3.97	1.48E+01		1737.0	1639	542	2.29	< 1.00E-01
	1846.0	1631	532	3.81	4.90E+00		1738.0	1637	516	3.05	< 1.00E-01
	1847.0	1639	535	3.66	3.43E+00		1739.0	1631	487	3.36	< 1.00E-01
	1848.0	1660	549	3.36	3.11E+00		1745.0	1632	407	4.12	< 1.00E-01

Appendix D-6

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)
74	1750.0	1648	386	4.27	< 1.00E-01	74	1918.0	1647	457	4.58	2.30E-01
	1755.0	1657	382	4.42	< 1.00E-01		1919.0	1720	445	4.73	2.87E-01
	1800.0	1670	384	4.73	< 1.00E-01		1920.0	1806	433	4.73	< 1.00E-01
	1805.0	1679	386	4.88	< 1.00E-01		1921.0	1880	424	4.73	< 1.00E-01
	1810.0	1684	387	4.88	< 1.00E-01		1922.0	1961	421	4.58	< 1.00E-01
	1815.0	1690	390	5.03	< 1.00E-01		1923.0	2036	422	4.73	< 1.00E-01
	1820.0	1701	394	5.19	< 1.00E-01		1924.0	2103	428	4.58	< 1.00E-01
	1825.0	1710	400	4.58	1.32E-01		1925.0	2156	431	4.42	< 1.00E-01
	1830.0	1717	412	4.42	1.94E-01		1926.0	2209	435	4.27	< 1.00E-01
	1835.0	1724	439	4.58	6.24E-01		1926.5	2239	440	4.27	c 1.00E-01
	1836.0	1723	449	4.58	6.73E-01		1927.0	2267	458	4.27	< 1.00E-01
	1837.0	1721	457	4.42	1.41 E+00		1927.5	2295	463	4.42	< 1.00E-01
	1838.0	1717	465	4.42	1.45E+O0		1928.0	2318	455	4.42	< 1.00E-01
	1839.0	1707	470	4.42	2.63E+00		1928.5	2346	453	4.58	< 1.00E-01
	1840.0	1693	470	4.42	2.20E+O0		1929.0	2370	457	4.73	< 1.00E-01
	1841.0	1685	466	4.42	2.00E+00		1929.5	2393	459	4.73	c 1.00E-01
	1842.0	1677	463	4.27	7.79E-01		1930.0	2411	464	4.58	c 1.00E-01
	1843.0	1668	457	4.42	6.73E-01	75	1734.0	1640	625	0.61	< 1.00E-01
	1844.0	1659	447	4.27	2.08E-01		1735.0	1637	585	1.83	< 1.00E-01
	1845.0	1646	440	4.27	1.49E-01		1736.0	1632	561	2.29	c 1.00E-01
	1846.0	1635	435	4.27	1.08E-01		1737.0	1622	534	2.29	< 1.00E-01
	1847.0	1622	436	4.27	3.08E-01		1738.0	1612	507	2.59	< 1.00E-01
	1848.0	1608	442	4.42	2.43E-01		1739.0	1599	467	3.05	< 1.00E-01
	1849.0	1594	452	4.42	5.55E-01		1740.0	1602	434	3.66	< 1.00E-01
	1850.0	1582	462	4.27	3.25E-01		1745.0	1635	412	4.12	< 1.00E-01
	1852.0	1560	503	4.42	5.08E + 00		1750.0	1662	410	4.73	< 1.00E-01
	1853.0	1572	498	4.42	1.94E+O0		1755.0	1678	411	4.68	< 1.00E-01
	1854.0	1562	506	4.58	3.87E+00		1800.0	1687	412	5.19	< 1.00E-01
	1855.0	1544	519	4.58	1.20E+01		1805.0	1696	415	5.34	< 1.00E-01
	1856.0	1531	534	4.73	7.26E+00		1810.0	1706	419	4.73	< 1.00E-01
	1857.0	1505	550	4.58	4.76E+00		1815.0	1712	422	4.27	1.43E-01
	1859.0	1533	544	4.42	7.25E +00		1820.0	1717	426	4.73	4.20E-01
	1900.0	1556	528	4.42	7.57E + 00		1825.0	1723	431	4.27	5.40E-01
	1901.0	1580	517	4.58	8.26E+00		1830.0	1729	437	4.42	1.64E-01
	1914.0	1575	516	4.42	6.36E +00		1835.0	1737	447	4.27	c 1.00E-01
	1916.0	1572	518	4.27	5.04E+00		1840.0	1741	468	4.12	1.58E+00
	1917.0	1578	492	4.42	2.35E+00		1841.0	1728	484	4.12	8.78E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
75	1842.0	1728	481	3.97	1.59E+O0	76	1739.0	1628	449	3.51	c 1.00E-01
	1643.0	1721	483	3.97	5.46E+00		1742.0	1637	401	3.81	< 1.00E-01
	1844.0	1712	486	4.12	4.76E+00		1743.0	1649	398	3.97	c 1.00E-01
	1845.0	1703	486	4.12	4.20E+00		1744.0	1658	397	4.12	< 1.00E-01
	1846.0		483	4.12	3.84E+00		1745.0	1674	402	4.12	< 1.00E-01
	1847.0	1689	473	4.12	1.75E+O0		1750.0	1694	408	4.27	< 1.00E-01
	1848.0	1685	457	4.27	7.96E-01		1755.0	1703	412	4.42	< 1.00E-01
	1849.0	1676	441	4.42	2.75E-01		1800.0	1713	417	4.73	< 1.00E-01
	1850.0	660	433	4.27	2.11 E-CM		1805.0	1720	420	5.o3	< 1.00E-01
	1851.0	1643	431	4.27	1.45E-01		1810.0	1727	423	4.88	< 1.00E-01
	1852.0	1628	437	4.12	< 1.00E-01		1815.0	1732	427	5.03	2.26E-01
	1853.0	1612	449	4.12	2.18E-01		1820.0	1736	430	4.88	2.80E-01
	1854.0	1602	458	4.12	4.77E-01		1825.0	1742	434	4.88	3.09E-01
	1855.0	1591	470	4.12	8.54E-01		1830.0	1749	441	4,73	2.76E-01
	1856.0	1568	483	3.97	9.36E-01		1831.0	1751	445	4.73	2.36E-01
	1857.0	1416	521	3.81	5.07E+00		1832.0	1752	449	4.58	1.86E-01
	1858.0	1407	523	4.12	3.69E+00		1833.0	1753	451	4.58	1.12E+00
	1859.0	1386	524	4.27	1.47E+O0		1834.0	1752	453	4.73	9.89E-01
	1900.0	1370	525	4,27	3.82E+00		1835.0	1750	456	4.73	7.66E-01
	1901.0	1344	525	4.73	2.41 E+00		1836.0	1747	459	4.73	5.50E-01
	1915,0	1362	514	4.58	3.42E+O0		1837.0	1744	462	4.58	3.55E-01
	1916.5	1457	474	4.42	1.13E-01		1838.0	1738	465	4.58	1.37E-01
	1918.0	1553	430	4.27	< 1.00E-01		1839.0	1733	467	4.58	1.62E+ 00
	1919.5	1632	413	4.27	< 1.00E-01		1841.0	1721	470	4.73	2.89E+00
	1921.0	1726	396	4.42	< 1.00E-01		1842.0	1711	472	4.58	2.58E+00
	1924.0	1897	381	4.27	< 1.00E-01		1843.0	1700	469	4.42	2.26E+00
	1925.5	1992	376	4.12	< 1.00E-01		1844.0	1690	468	4.42	2.00E+O0
	1927.0	2099	384	4.12	< 1.00E-01		1845.0	1683	467	4.42	1.82E+ 00
	1928.5	2202	412	4.27	< 1.00E-01		1846.0	1674	466	4.42	1.64E+O0
	1930.0	2289	451	4.42	< 1.00E-01		1847.0	1660	462	4.42	4.84E-01
	1931.5	2350	454	4.42	< 1.00E-01		1848.0	1647	461	4.42	3.44E-01
	1933.0	2403	462	4.58	< 1.00E-01		1849.0	1633	461	4.42	1.63E-01
76	1734.0	1641	627	0.46	< 1.00E-01		1850,0	1617	462	4.42	6.05E-01
	1735.0	1644	582	1.83	< 1.00E-01		1851.0	1607	464	4.42	4.95E-01
	1736.0	1643	557	2.29	< 1.00E-01		1852.0	1595	466	4.27	1.18E+00
	1737.0	1627	518	2.44	< 1.00E-01		1853.0	1581	470	4.27	7.1 5E-01
	1738.0	1632	486	3.20	< 1.00E-01		1854.0	1569	474	4.27	3.30E-01

Appendix D-6

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)
76	1855.0	1556	478	4.27	9.32E-01	77	1845.0	1599	476	4.12	2.90E+00
	1856.0	1530	490	4.42	4.19E+00		1850.0	1582	469	4.27	8.46E-01
	1857.0	1508	493	4.42	1.82E+O0		1855.0	1576	457	3.97	2.98E-01
	1858.0	1482	496	4.58	2.92E+00		1900.0	1585	446	3.81	1.12E-01
	1859.0	1452	496	4.58	5.43E-01		1905.0	1620	444	4.12	2.02E-01
	1900.0	1417	494	4.58	1.71E+00		1910.0	1708	449	4.42	2.75E-01
	1916.0	1484	437	4.27	1.17E-01		1913.0	1773	448	4.58	< 1.00E-01
	1917.0	1540	440	4.27	1.42E-01		1914.0	1824	445	4.73	< 1.00E-01
	1918.0	1596	438	4.58	1.24E-01		1915.0	1894	441	4.58	< 1.00E-01
	1919.0	1649	437	4.73	c 1.00E-01		1916.0	1978	440	4.27	< 1.00E-01
	1920.0	1710	434	4.58	2.42E-01		1917.0	2063	443	4.42	< 1.00E-01
	1921.0	1776	432	4.58	1.83E-01		1917.5	2104	450	4.42	< 1.00E-01
	1922.0	1839	429	4.73	< 1.00E-01		1918.0	2143	453	4.42	5.75E-01
	1923.0	1902	427	4.58	< 1.00E-01		1918.5	2189	458	4.58	6.74E-01
	1924.0	1970	428	4.42	< 1.00E-01		1919.0	2233	487	4.58	1.62E-01
	1925.0	2029	431	4.42	< 1.00E-01		1919.5	2273	484	4.42	< 1.00E-01
	1926.0	2090	434	4.27	< 1.00E-01		1920.0	2313	485	4.42	< 1.00E-01
	1929.0	2279	447	4.58	c 1.00E-01		1920.5	2345	485	4.58	< 1.00E-01
	1932.0	2400	452	4.27	c 1.00E-01		1921.0	2370	485	4.73	< 1.00E-01
77	1734.0	1643	614	0.61	< 1.00E-01		1921.5	2401	486	4.58	c 1.00E-01
	1735.0	1645	598	1.37	< 1.00E-01		1922.0	2428	487	4.58	< 1.00E-01
	1736.0	1645	582	2.44	< 1.00E-01	78	1734.0	1645	598	0.61	< 1.00E-01
	1737.0	1645	572	3.51	< 1.00E-01		1735.0	1635	589	1.83	c 1.00E-01
	1738.0	1644	560	3.97	< 1.00E-01		1736.0	1625	568	1.98	< 1.00E-01
	1739.0	1641	544	4.27	< 1.00E-01		1737.0	1614	543	2.44	< 1.00E-01
	1740.0	1640	529	4.58	< 1.00E-01		1738.0	1604	520	2.59	< 1.00E-01
	1745.0	1635	500	4.58	1.85E-01		1739.0	1588	485	3.05	c 1.00E-01
	1750.0	1635	486	4.88	< 1.00E-01		1740.0	1582	463	3.51	< 1.00E-01
	1755.0	1636	479	5.34	3.33E-01		1745.0	1597	425	4.42	< 1.00E-01
	1800.0	1636	476	5.64	6.23E-01		1750.0	1612	414	4.58	< 1.00E-01
	1805.0	1639	473	5.19	3.43E-01		1755.0	1620	407	5.03	< 1.00E-01
	1810.0	1643	470	5,03	5.79E-01		1800.0	1631	400	5.19	< 1.00E-01
	1815.0	1645	466	4.88	8.58E-01		1805.0	1639	394	5.34	< 1.00E-01
	1825.0	1639	461	4.73	2.82E-01		1810.0	1649	390	4.88	< 1.00E-01
	1830.0	1632	466	4.58	8.39E-01		1815.0	1661	381	4.58	< 1.00E-01
	1835.0	1623	471	4.42	1.53E+O0		1820.0	1685	374	4.73	< 1.00E-01
	1840.0	1612	476	3.97	3.50E +00		1825.0	1714	373	4.12	< 1.00E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
78	1830.0	1732	395	3.66	c 1.00E-01	79	1739.0	1578	438	3.97	c 1.00E-01
	1835.0	1720	405	4.27	1.85E-01		1740.0	1594	416	4.27	< 1.00E-01
	1840.0	1704	414	4.73	1.75E-01		1745.0	1644	395	4.42	< 1.00E-01
	1845.0	1683	430	4.88	3.36E-01		1750.0	1673	395	4.58	< 1.00E-01
	1846.0	1675	434	4.88	2.93E-01		1755.0	1687	398	4.73	< 1.00E-01
	1847.0	1672	439	4.73	2.73E-01		1800.0	1696	402	4.73	< 1.00E-01
	1848.0	1669	450	4.73	2.37E-01		1805.0	1701	409	4.88	< 1.00E-01
	1849.0	1673	459	4.58	6.37E-01		1810.0	1702	417	4.73	< 1.00E-01
	1850.0	1684	463	4.58	7.27E-01		1815.0	1683	432	4,73	2.67E-01
	1851.0	1703	469	4.58	2.00E +00		1820.0	1643	437	4.42	1.26E-01
	1852.0	1720	485	4.58	4.26E+00		1825.0	1648	453	4.58	4.87E-01
	1853.0	1709	497	4.42	6.50E +00		1830.0	1670	455	5.03	7.84E-01
	1854.0	1678	454	4.42	6.49E-01		1835.0	1681	456	5.19	9.00E-01
	1859.0	1515	493	4.58	2.25E+00		1840.0	1689	459	4.88	9.72E-01
	1900.0	1466	495	4.42	1.67E +00		1841.0	1692	461	5.03	9.97E-01
	1901.0	1402	497	4.27	1.1OE+OO		1842.0	1694	464	4.88	1.02E+O0
	1914.0	1404	450	4.27	< 1.00E-01		1843.0	1694	470	4.88	2.1 1E+00
	1915.5	1455	441	4.42	< 1.00E-01		1844.0	1692	474	4.73	1.95E +00
	1917.0	1501	443	4.12	< 1.00E-01		1845.0	1689	476	4.73	4.08E+00
	1918.5	1558	443	3.97	< 1.00E-01		1846.0	1682	481	4.73	3.40E+00
	1920.0	1603	430	4.12	1.49E-01		1847.0	1672	484	4.58	2.64E+00
	1921.5	1679	450	3.97	1.61 E-01		1848.0	1663	485	4.73	2.00E+00
	1923.0	1752	456	3.81	3.03E-01		1849.0	1653	487	4.73	1.31E+00
	1924.5	1826	457	3.97	< 1.00E-01		1850.0	1645	489	4.73	3.85E +00
	1926.0	1891	446	4.27	< 1.00E-01		1851.0	1631	488	4.73	3.00E+00
	1927.5	1959	433	4.42	< 1.00E-01		1852.0	1620	488	4.58	7.34E+ 00
	1929.0	2028	413	4.58	< 1.00E-01		1853.0	1606	487	4.58	1.98E+O0
	1930.5	2118	401	4.42	< 1.00E-01		1854.0	1593	486	4.58	1.58E+00
	1932.0	2198	408	4.27	< 1.00E-01		1855.0	1579	486	4.58	1.07E +00
	1933.5	2272	443	4.58	< 1.00E-01		1856.0	1550	490	4.42	1.78E +00
	1935.0	2334	447	4.42	< 1.00E-01		1857.0	1525	490	4.58	3.73E+00
	1936.5	2388	458	4.73	< 1.00E-01		1858.0	1488	489	4.58	3.99E +00
79	1734.0	1645	606	0.61	< 1.00E-01		1859.0	1451	491	4.73	1.10E+00
	1735.0	1626	572	1.68	< 1.00E-01		1800.0	1414	494	4.58	1.60E+O0
	1736.0	1614	543	2.29	< 1.00E-01		1901.0	1399	495	4.42	1.04E +00
	1737.0	1597	511	3.05	< 1.00E-01		1914.0	1383	479	4.73	3.96E-01
	1738.0	1580	470	3.81	< 1.00E-01		1915.0	1394	476	4.42	3.58E-01

Appendix D-6

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)
79	1916.0	1434	472	4.42	3.37E-01	81	1740.0	1647	451	4.42	c 1.00E-01
	1917.0	1463	468	4.27	2.94E-01		1745.0	1671	442	4.73	c 1.00E-01
	1918.0	1489	463	4.42	2.40E-01		1750.0	1679	436	4.58	< 1.00E-01
	1919.0	1516	461	4.27	1.45E-01		1755.0	1687	432	4.73	c 1.00E-01
	1920.0	1552	454	4.42	1.1 8E-01		1800.0	1689	429	4.88	1.21 E-01
	1921.0	1586	448	4.58	c 1.00E-01		1805.0	1693	425	5.19	c 1.00E-01
	1922.0	1620	444	4.58	1.58E-01		1810.0	1700	421	5.03	< 1.00E-01
	1923.0	1668	438	4.58	1.33E-01		1815.0	1697	417	5.34	1.09E-01
	1924.0	1709	430	4.73	2.28E-01		1820.0	1699	414	5.19	1.27E-01
	1925.0	1754	428	4.58	1.51 E-01		1825.0	1702	405	4.88	1.34E-01
	1926.0	1794	424	4.58	< 1.00E-01		1830.0	1700	401	4.58	1.39E-01
	1927.0	1833	424	4.42	< 1.00E-01		1831.0	1698	400	4.58	1.34E-01
	1928.0	1880	422	4.73	< 1.00E-01		1832.0	1697	399	4.73	c 1.00E-01
	1929.0	1926	424	4.73	< 1.00E-01		1833.0	1695	397	4.58	c 1.00E-01
	1930.0	1971	423	4.58	< 1.00E-01		1834.0	1693	396	4.42	< 1.00E-01
	1931.0	2011	419	4.42	< 1.00E-01		1835.0	1694	396	4.42	< 1.00E-01
	1932.0	2052	416	4.42	< 1.00E-01		1836.0	1688	394	4.42	< 1.00E-01
	1933.0	2099	411	4.58	< 1.00E-01		1837.0	1686	394	4.42	< 1.00E-01
	1937.0	2301	431	4.58	< 1.00E-01		1838.0	1681	394	4.27	< 1.00E-01
	1938.0	2342	426	4.42	c 1.00E-01		1839.0	1678	394	4.42	< 1.00E-01
	1939.0	2342	426	4.73	c 1.00E-01		1840.0	1676	395	4.42	< 1.00E-01
80	1734.0	1644	605	0.92	< 1.00E-01		1841.0	1669	396	4.42	c 1.00E-01
	1734.5	1639	593	2,29	< 1.00E-01		1842.0	1663	398	4.58	< 1.00E-01
	1735.0	1624	579	2.59	< 1.00E-01		1843.0	1657	398	4.42	c 1.00E-01
	1735.5	1617	573	3.05	< 1.00E-01		1844.0	1652	400	4.42	< 1.00E-01
	1736.0	1596	545	3.20	< 1.00E-01		1845.0	1647	402	4.27	< 1.00E-01
	1736.5	1571	527	2.75	< 1.00E-01		1846.0	1639	404	4.27	< 1.00E-01
	1737.0	1536	512	3.81	< 1.00E-01		1847.0	1631	407	4.27	< 1.00E-01
	1737.5	1498	503	4.12	< 1.00E-01		1848.0	1624	412	4.42	1.1 3E-01
	1738.0	1456	501	4.27	< 1.00E-01		1849.0	1616	416	4.42	< 1.00E-01
	1738.5	1405	503	4.42	< 1.00E-01		1850.0	1609	423	4.42	< 1.00E-01
81	1734.0	1643	613	0.76	c 1.00E-01		1851.0	1601	428	4.42	2.46E-01
	1735.0	1640	587	2.14	c 1.00E-01		1852.0	1591	433	4.58	1.91 E-01
	1736.0	1635	566	2.59	< 1.00E-01		1853.0	1579	444	4.58	1.17E-01
	1737.0	1631	534	2.90	< 1.00E-01		1854.0	1568	457	4.42	2.49E-01
	1738.0	1628	492	3.51	< 1.00E-01		1855.0	1555	468	4.58	4.34E-01
	1739.0	1635	460	3.97	< 1.00E-01		1856.0	1532	488	4.73	4.71E+00

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
81	1857.0	1509	497	4.58	1.32E +00	82	1738.0	1639	558	2.29	< 1.00E-01
	1858.0	1479	503	4.73	6.32E +00		1739.0	1640	540	2.90	< 1.00E-01
	1859.0	1441	503	4.58	5.17E+00		1740.0	1650	524	3.20	< 1.00E-01
	1900.0	1402	501	4.42	2.79E+00		1745.0	1703	494	3.97	4.1 6E-01
	1901.0	1347	501	4.58	2.23E+00		1750.0	1715	485	4.88	6.64E-01
	1914.0	1355	503	4.42	1.75E+O0		1755.0	1719	483	5.03	1.40E+O0
	1915.0	1388	489	4.58	6.44E-01		1800.0	1721	479	4.73	2.20E+00
	1916.0	1418	477	4.58	5.57E-01		1805.0	1723	475	4.88	3.14E+00
	1917.0	1452	464	4.73	< 1.00E-01		1810.0	1725	470	4.42	2.24E+O0
	1918.0	1488	452	4.58	2.82E-01		1815.0	1725	465	4.73	1.40E+O0
	1919.0	1532	443	4.73	1.06E-01		1820.0	1725	460	4.27	1.46E+O0
	1920.0	1567	433	4.58	c 1.00E-01		1825.0	1723	449	4.42	6.78E-01
	1921.0	1600	427	4.42	1.49E-01		1830.0	1715	433	4.27	5.49E-01
	1922.0	1641	420	4.27	< 1.00E-01		1835.0	1697	418	4.27	1.68E-01
	1924.0	1713	402	4.42	< 1.00E-01		1836.0	1693	416	4.27	1.56E-01
	1924.5	1730	397	4.27	< 1.00E-01		1837.0	1686	413	4.42	1.38E-01
	1925.0	1747	392	4.27	< 1.00E-01		1838.0	1679	410	4.42	1.23E-01
	1925.5	1771	386	4.42	c 1.00E-01		1839.0	1674	409	4.27	1.1 3E-01
	1926.0	1790	384	4.58	< 1.00E-01		1840.0	1665	408	4.12	< 1.00E-01
	1926.5	1826	369	4.58	< 1.00E-01		1841.0	1656	409	4.12	< 1.00E-01
	1927.0	1837	382	4.73	< 1.00E-01		1842.0	1644	409	4.12	< 1.00E-01
	1927.5	1860	383	4.73	< 1.00E-01		1643.0	1629	416	4.12	< 1.00E-01
	1928.0	1886	387	4.73	< 1.00E-01		1844.0	1618	424	3.97	< 1.00E-01
	1928.5	1903	385	4.73	< 1.00E-01		1845.0	1607	434	3.97	2.61 E-01
	1929.0	1926	384	4.58	< 1.00E-01		1846.0	1600	442	3.81	2.1 7E-01
	1930.0	1973	387	4.42	< 1.00E-01		1847.0	1592	451	3.81	5.54E-01
	1931.0	2018	386	4.27	c 1.00E-01		1648.0	1583	460	3.97	3.57E-01
	1932.0	2074	388	4.42	< 1.00E-01		1849.0	1571	468	3.97	7.38E-01
	1933.0	2132	392	4.42	< 1.00E-01		1850.0	1558	475	4.12	1.44E-01
	1934.0	2188	400	4.58	< 1.00E-01		1851.0	1542	485	4.12	2.22E+00
	1935.0	2251	405	4.58	c 1.00E-01		1852.0	1529	491	3.97	4.38E +00
	1936.0	2304	420	4.73	c 1.00E-01		1653.0	1515	496	4.12	2.05E +00
	1938.0	2304	420	4.58	< 1.00E-01		1854.0	1498	500	4.12	9.90E+00
82	1734.0	1643	614	0.46	< 1.00E-01		1855.0	1481	502	4.12	6.97E+00
	1735.0	1644	597	1.68	< 1.00E-01		1856.0	1466	504	4.27	4.28E +00
	1736.0	1642	585	1.22	c 1.00E-01		1857.0	1448	504	4.42	5.72E+00
	1737.0	1641	572	1.83	< 1.00E-01		1858.0	1426	503	4.42	4.23E+00

Appendix D-6

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)	Fish No.	Time	X (m)	Y (m)	Depth (m)	Conc (ppb)
82	1859.0	1399	503	4.27	2.55E +00	83	1743.0	1688	444	4.73<	1.00E-01
	1900.0	1370	509	4.42	2.62E +00		1743.5	1702	458	5.19<	1.00E-01
	1914.5	1374	524	4.27	3.42E+00		1744.0	1723	472	4.42	2.19E-01
	1916.0	1430	490	4.12	1.50E+00		1744.5	1734	484	4.73	2.14E-01
	1917.5	1488	483	3.97	1.10E+00		1745.0	1743	491	4.73	6.06E-01
	1919.0	1538	478	4.12	1.54E +00		1745.5	1750	498	4.27	5.72E-01
	1920.5	1593	467	4.12	6.75E-01		1746.0	1751	506	2.14	6.82E-01
	1922.0	1663	458	3.97	3.1 6E-01		1746.5	1749	516	2.44	4.92E-01
	1923.5	1729	443	4.12<	1.00E-01		1747.0	1756	524	2.14	2.12E-01
	1925.0	1805	432	4.27<	1.00E-01		1747.5	1768	532	1.98	2.60E-01
	1926.5	1881	427	4.12<	1.00E-01		1748.0	1780	530	2.59	3.90E-01
	1928.0	1969	428	4.27<	1.00E-01		1748.5	1792	523	3.66	5.98E-01
	1929.5	2041	439	4.27<	1.00E-01		1749.0	1792	502	3.51	2.11 E+00
	1931.0	2106	432	4.42<	1.00E-01		1749.5	1784	483	2.29	1.47E +00
	1932.5	2176	439	4.42<	1.00E-01		1750.0	1770	463	2.75	3.89E-01
	1934.0	2241	469	4.27	7.44E-01		1750.5	1750	456	4.88	2.49E-01
	1935.5	2303	466	4.42<	1.00E-01		1751.0	1731	460	4.42<	1.00E-01
	1937.0	2355	471	4.58 c	1.00E-01		1752.0	1695	482	5.34	7.49E-01
	1938.5	2399	478	4.58<	1.00E-01		1753.0	1659	513	3.66	6.70E-01
83	1734.0	1644	597	0.61 <	1.00E-01		1754.0	1633	530	4.12	2.04E-01
	1734.5	1628	588	3.05<	1.00E-01		1755.0	1608	530	3.51	2.19E-01
	1735.0	1617	573	3,36<	1.00E-01		1756.0	1597	520	3.66	3.46E-01
	1735.5	1596	534	3.97<	1.00E-01		1757.0	1587	509	4.42	4.72E-01
	1736.0	1591	490	4.88 c	1.00E-01		1758.0	1583	501	4.27	8.15E-01
	1736.5	1598	460	5.03 c	1.00E-01		1759.0	1574	485	2.75	2.83E-01
	1737.0	1607	436	4.88<	1.00E-01		1800.0	1567	474	2.44	1.29E-01
	1737.5	1618	412	4.88<	1.00E-01		1801.0	1565	465	2.75 c	1.00E-01
	1738.0	1648	388	4.42<	1.00E-01		1802.0	1568	455	2.90	1.05E-01
	1738.5	1664	395	3.66<	1.00E-01		1803.0	1572	444	2.75<	1.00E-01
	1739.0	1675	396	2.14<	1.00E-01		1804.0	1578	432	2.75	<1.00E-01
	1739.5	1692	404	2.59<	1.00E-01		1805.0	1586	418	3.05	<1.00E-01
	1740.0	1702	408	2.44<	1.00E-01		1806.0	1591	407	3.05	<1.00E-01
	1740.5	1710	413	1.83<	1.00E-01		1808.0	1601	379	2.75<	1.00E-01
	1741.0	1719	422	2.29<	1.00E-01		1809.0	1613	366	2.44<	1.00E-01
	1741.5	1710	430	2.75<	1.00E-01		1810.0	1629	376	2.29<	1.00E-01
	1742.0	1697	431	5.34<	1.00E-01		1811.0	1640	386	2.59<	1.00E-01
	1742.5	1688	432	3.66<	1.00E-01		1812.0	1648	396	2.90<	1.00E-01

Appendix D-6

Continued

Fish No.	Time	X (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
83	1813.0	1655	402	3.66<	1.00E-01	83	1850.0	1624	427	4.42	3.29E-01
	1814.0	1660	407	4.58<	1.00E-01		1851.0	1619	428	4.27	3.04E-01
	1815.0	1665	411	5.03 <	1.00E-01		1852.0	1609	426	4.12	2.69E-01
	1816.0	1669	415	5.03 c	1.00E-01		1853.0	1598	424	3.66 c	1.00E-01
	1817.0	1670	418	4.88<	1.00E-01		1854.0	1573	429	3.66	1.43E-01
	1818.0	1673	423	4.42<	1.00E-01		1855.0	1558	447	3.81 <	1.00E-01
	1819.0	1680	429	4.27	2.82E-01		1856.0	1543	470	3.66	1.03E+o0
	1820.0	1683	436	3.97	3.29E-01		1857.0	1509	492	3.97	1.95E+o0
	1821.0	1688	448	4.12	4.14E-01		1858.0	1463	499	3.81	1.16E+00
	1822.0	1692	460	3.51	1.02E+00		1859.0	1415	501	3.97	3.65E+00
	1823.0	1696	469	3.20	2.23E+00		1900.0	1355	503	4.12	2.42E+00
	1824.0	1699	491	3.05	9.07E + 00		1913.0	1377	505	3.97	6.94E-01
	1825.0	1698	507	3.20	1.16E+01		1914.0	1491	481	3.97	1.26E+O0
	1826.0	1691	523	2.75	7.49E +00		1914.5	1556	458	3.81	1.06E-01
	1827.0	1668	516	2.90	1.02E +01		1915.0	1609	436	3.97	1.61 E-01
	1828.0	1659	497	3.20	4.60E+00		1915.5	1669	418	3.97	<1.00E-01
	1829.0	1653	486	3.36	2. 01E+00		1916.0	1748	402	4.12 c	1.00E-01
	1830.0	1651	479	3.81	2.37E +00		1916.5	1857	390	3.66 c	1.00E-01
	1831.0	1647	474	4.27	7.84E-01		1917.0	1951	393	3.51	<1.00E-01
	1832,0	1646	469	4.73	1.01 E+00		1917.5	2058	390	3.66 c	1.00E-01
	1833.0	1644	464	5.34	3.28E-01		1918.0	2137	408	3.97	<1.00E-01
	1834.0	1641	457	5.03	3.76E-01		1918.5	2208	426	4.12	1.46E-01
	1835.0	1638	451	4.88	4.16E-01		1919.0	2273	458	4.27<	1.00E-01
	1836.0	1633	443	5.03<	1.00E-01		1919.5	2437	575	4.12 c	1.00E-01
	1837.0	1628	433	4.42<	1.00E-01	64	1734.0	1646	599	0.61 c	1.00E-01
	1838.0	1622	418	3.97	1.02E-01		1735.0	1640	579	1.37<	1.00E-01
	1839.0	1621	404	3.81	1.13E-01		1736.0	1636	554	2.29<	1.00E-01
	1840.0	1627	384	3.36<	1.00E-01		1737.0	1629	523	3.20<	1.00E-01
	1841.0	1637	375	3.20	<1.00E-01		1738.0	1621	488	3.97<	1.00E-01
	1842.0	1654	371	3.05<	1.00E-01		1739.0	1615	451	4.27<	1.00E-01
	1843.0	1673	376	3.51 <	1.00E-01		1740.0	1615	412	4.42<	1.00E-01
	1844.0	1686	393	3.81 <	1.00E-01		1745.0	1674	397	4.27 c	1.00E-01
	1845.0	1679	410	3.97	1.13E-01		1750.0	1690	405	4.42 c	1.00E-01
	1846.0	1661	420	4.27<	1.00E-01		1755.0	1698	412	4.73<	1.00E-01
	1847.0	1649	422	4.73<	1.00E-01		1800.0	1705	416	4.58<	1.00E-01
	1848,0	1642	423	4.73<	1.00E-01		1805.0	1711	418	4.88<	1.00E-01
	1849.0	1633	426	4.88	1.26E-01		1810.0	1715	423	4.68	1.19E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
84	1815.0	1720	428	5.03	3.77E-01	84	1928.0	2013	461	4.27	1.29E-01
	1820.0	1727	433	5.03	1.65E-01		1929.0	2064	402	4.27	< 1.00E-01
	1825.0	1735	440	4.88	1.81 E-01		1933.0	2337	442	4.58	< 1.00E-01
	1830.0	1743	447	4.73	1.64E-01		1934.0	2383	446	4.73	c 1.00E-01
	1835.0	1746	456	4.73	7.46E-01		1935.0	2416	450	4.58	< 1.00E-01
	1836.0	1741	458	4.73	5.47E-01	85	1734.0	1647	600	0.61	< 1.00E-01
	1837.0	1736	458	4.73	4.90E-01		1735.0	1641	576	1.98	< 1.00E-01
	1838.0	1731	457	4.58	4.33E-01		1736.0	1644	536	2.59	< 1.00E-01
	1839.0	1726	458	4.58	3.40E-01		1737.0	1637	511	3.05	< 1.00E-01
	1840.0	1721	460	4.58	1.41 E+00		1738.0	1615	496	3.51	< 1.00E-01
	1841.0	1716	458	4.42	1.30E+o0		1739.0	1590	479	3.66	< 1.00E-01
	1842.0	1708	457	4.42	1.1 6E+00		1740.0	1588	452	3.97	< 1.00E-01
	1843.0	1699	456	4.27	1.03E+00		1745.0	1622	425	4.12	< 1.00E-01
	1850.0	1615	436	4.58	2.78E-01		1750.0	1644	425	4.27	< 1.00E-01
	1851.0	1614	446	4.73	2.41 E-01		1755.0	1658	426	4.73	< 1.00E-01
	1852.0	1606	456	4.73	5.58E-01		1800.0	1688	426	4.73	< 1.00E-01
	1853.0	1592	462	4.58	3.73E-01		1805.0	1676	425	4.88	1.32E-01
	1854.0	1581	469	4.58	7.76E-01		1810.0	1686	424	5.03	< 1.00E-01
	1855.0	1588	476	4.58	1.49E+00		1815.0	1689	422	4.88	1.06E-01
	1856.0	1552	483	4.58	4.41 E-01		1820.0	1696	421	5.19	1.36E-01
	1857.0	1530	495	4.42	3.51 E+00		1825.0	1699	419	5.03	1.58E-01
	1858.0	1506	498	4.27	7.67E-01		1830.0	1705	419	4.73	1.86E-01
	1859.0	1473	499	4.42	1.91 E+00		1835.0	1710	423	4.58	2.07E-01
	1900.0	1437	500	4.27	4.85E+00		1836.0	1710	426	4.58	4.86E-01
	1901.0	1390	500	4.42	5.96E-01		1837.0	1712	427	4.42	5.01 E-01
	1902.0	1342	504	4.58	1.87E+O0		1838.0	1711	431	4.42	5.13E-01
	1915.0	1354	510	4.58	1.49E+O0		1839.0	1712	433	4.58	5.20E-01
	1916.0	1408	504	4.58	2.1 6E +00		1840.0	1712	436	4.58	5.23E-01
	1917.0	1449	497	4.27	1.96E +00		1841.0	1709	439	4.58	5.1oE-O1
	1918.0	1491	489	4.42	2.84E + 00		1842.0	1707	443	4.42	4.97E-01
	1919.0	1538	481	4.27	1.39E+O0		1843.0	1703	446	4.27	4.73E-01
	1920.0	1587	472	4.58	4.66E-01		1844.0	1697	448	4.42	4.30E-01
	1921.0	1642	463	4.58	1.45E-01		1845.0	1692	451	4.42	9.23E-01
	1922.0	1696	451	4.73	5.18E-01		1846.0	1684	453	4.42	8.35E-01
	1923.0	1750	445	4.73	< 1.00E-01		1848.0	1665	457	4.27	5.86E-01
	1926.0	1926	434	4.58	c 1.00E-01		1849.0	1652	458	4.27	4.19E-01
	1927.0	1985	430	4.42	< 1.00E-01		1850.0	1637	462	4.27	2.01 E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
65	1651.0	1625	465	4.27 c	1.00E-01	86	1745.0	1665	404	4.27<	1.00E-01
	1852.0	1611	467	4.27	1.37E+O0		1750.0	1679	401	4.42<	1.00E-01
	1853.0	1597	467	4.27	1.11E+00		1755.0	1694	403	4.42<	1.00E-01
	1854.0	1579	469	4.27	7.46E-01		1800.0	1702	407	4.73<	1.00E-01
	1855.0	1560	472	4.27	3.07E-01		1805.0	1711	412	5.03 c	1.00E-01
	1856.0	1522	479	4.42	1.52E+O0		1810.0	1721	421	4.42	1.22E-01
	1657.0	1491	482	4.27	1.74E +00		1815.0	1729	428	4.88	1.93E-01
	1858.0	1449	497	4.42	2.95E+00		1820.0	1742	439	4.58	2.60E-01
	1859.0	1410	506	4.42	3.07E+00		1825.0	1757	456	4.27	1.08E +00
	1900.0	1352	511	4.58	1.91 E +00		1830.0	1765	479	4.12	4.82E+00
	1914.0	1321	526	4.58	3.31 E+00		1831.0	1765	484	3.97	3.03E +00
	1915.0	1369	511	4.73	1.65E+O0		1832.0	1764	489	3.97	1.04E+01
	1916.0	1404	508	4.58	1.76E +00		1833.0	1760	497	4.12	6.01E+00
	1917.0	1433	501	4.73	3.26E+00		834.0	756	501	4.12	1.58E+01
	1918.0	1469	494	4.73	1.47E+O0		835.0	750	503	4.12	1.26E+01
	1919.0	1503	487	4.58	1.27E-01		836.0	744	507	3.97	8.40E+00
	1920.0	1546	477	4.42	1.78E+O0		837.0	736	508	3.97	5.90E+00
	1921.0	1590	467	4.42	6.50E-01		838.0	727	506	3.81	6.15E+00
	1922.0	1643	457	4.27	2.00E-01		839.0	720	504	3.81	1.79E+01
	1923.0	1695	450	4.42	2.03E-01		840.0	712	500	3.81	1.82E+01
	1924.0	1752	443	4.58	<1.00E-01		841.0	708	496	3.81	9.27E + 00
	1927.0	1935	432	4.58<	1.00E-01		842.0	700	490	3.81	9.22E+ 00
	1928.0	1995	431	4.73<	1.00E-01		843.0	688	491	3.81	7.85E+00
	1929.0	2055	432	4.42<	1.00E-01		1844.0	1671	492	3.97	5.87E +00
	1930.0	2115	430	4.27	1.32E-01		1845.0	1654	493	3.97	4.25E +00
	1931.0	2167	433	4.42	1.66E-01		1846.0	1636	492	3.97	2.69E+00
	1932.0	2219	438	4.27	1.65E-01		1847.0	1609	489	4.12	6.78E+00
	1933.0	2272	458	4.42<	1.00E-01		1848.0	1571	482	4.12	1.30E+00
	1935.0	2369	452	4.58<	1.00E-01		1849.0	1580	482	4.12	1.61E+00
	1936.0	2398	461	4.73<	1.00E-01		1850.0	1597	472	4.12	9.81 E-01
86	1734.0	1644	597	0.76	<1.00E-01		1851.0	1609	459	4.12	5.58E-01
	1735.0	1637	581	2.44<	1.00E-01		1852.0	1603	444	4.27	2.05E-01
	1736.0	1632	537	2.59<	1.00E-01		1853.0	1587	458	4.42	3.81 E-01
	1737.0	1626	493	3.05 <	1.00E-01		1854.0	1579	471	4.27	6.61 E-01
	1738.0	1617	446	2.90<	1.00E-01		1855.0	1573	481	4.27	1.29E+O0
	1739.0	1626	433	3.36	<1.00E-01		1856.0	1545	486	4.58	2.04E+00
	1740.0	1636	420	3.81	<1.00E-01		1857.0	1508	491	4.42	2.12E+00

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
86	1858.0	1477	484	4,12	1.14E+00	87	1833.0	1696	438	4.58	4.65E-01
	1859.0	1442	505	4.27	5.23E+00		1834.0	1691	437	4.58	4.25E-01
	1900.0	1400	511	4.42	1.97E+O0		1835.0	1683	436	4.58	3.79E-01
	1901.0	1324	519	4.58	2.05E +00		1836.0	1675	436	4.58	3.34E-01
	1913.5	1357	485	4.12	3.47E-01		1837.0	1666	435	4.73	2.81 E-01
	1916.5	1483	474	4.27	4.11 E-01		1838.0	1658	435	4.73	2.40E-01
	1918.0	1532	472	4.27	5.1 OE-O1		1839.0	1646	435	4.73	1.75E-01
	1919.5	1606	457	4.42	3.40E-01		1840.0	1634	436	4.73	1.03E-01
	1921.0	1664	443	4.42	1.21E-01		1841.0	1628	438	4.73 c	1.00E-01
	1922.5	1739	431	4.27	1.06E-01		1842.0	1618	440	4.58	2.91 E-01
	1924.0	1819	418	4.12<	1.00E-01		1843.0	1610	446	4.58	2.47E-01
	1925.5	1897	410	4.42 c	1.00E-01		1844.0	1604	452	4.42	6.38E-01
	1930.0	2117	417	4.58<	1.00E-01		1845.0	1599	457	4.58	5.33E-01
	1931.5	2154	427	4.73<	1.00E-01		1846.0	1597	464	4.58	4.29E-01
	1933.0	2200	435	4.42	2.22E-01		1847.0	1595	473	4.42	9.00E-01
	1936.0	2287	465	4.27<	1.00E-01		1848.0	1591	480	4.42	2.20E+00
	1937.5	2327	467	4.12<	1.00E-01		1849.0	1590	488	4.27	5.47E+00
	1939.0	2362	470	4.27<	1.00E-01		1850.0	1587	494	4.27	4.03E+00
87	1734.0	1644	605	0.46<	1.00E-01		1851.0	1584	501	4.27	8.92E+00
	1735.0	1635	572	1.37<	1.00E-01		1852.0	1577	509	4.12	4.58E +00
	1736.0	1636	533	2.44<	1.00E-01		1853,0	1563	516	4.27	7.70E+00
	1737.0	1630	497	3.51 <	1.00E-01		1854.0	1554	519	4.27	4.59E+00
	1738.0	1627	472	3.81 <	1.00E-01		1855.0	1541	520	4.42	1.09E+ 01
	1739.0	1624	444	3.97<	1.00E-01		1856.0	1520	519	4.27	7.63E+00
	1740.0	1623	421	4.42<	1.00E-01		1857.0	1496	516	4.27	1.26E+01
	1745.0	1646	390	4.58<	1.00E-01		1858.0	1465	512	4.12	2.14E+00
	1750.0	1664	392	4.73 c	1.00E-01		1859.0	1423	511	4.12	3.76E+00
	1755.0	1674	394	4.58 <	1.00E-01		1900.0	1381	512	4.27	5.09E-01
	1800.0	1683	396	4.88 <	1.00E-01		1901.0	1357	510	4.27	2.07E+00
	1805.0	1688	397	5.03<	1.00E-01		1915.0	1334	475	4.42	2.79E-01
	1810.0	1695	397	5.03 c	1.00E-01		1916.0	1370	472	4.58	1.97E-01
	1815.0	1704	398	4.88<	1.00E-01		1917.0	1401	465	4.58<	1.00E-01
	1820.0	1713	403	4.73	1.21 E-01		1918.0	1434	463	4.42	1.67E-01
	1825.0	1725	412	4.73<	1.00E-01		1919.0	1468	459	4.42	1.42E-01
	1830.0	1719	433	4.58	5.69E-01		1920.0	1504	452	4.27	1.43E-01
	1831.0	1712	436	4.58	5.45E-01		1921.0	1543	448	4.12	1.25E-01
	1832.0	1705	437	4.42	5.12E-01		1922.0	1585	442	4.27<	1.00E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Conc (ppb)
87	1923.0	1627	436	4.42	< 1.00E-01	88	1840.0	1673	482	4.27	3.29E+00
	1929.0	1935	426	4.58	< 1.00E-01		1841.0	1666	483	4.27	2.70E+00
	1930.0	1987	428	4.58	c 1.00E-01		1842.0	1659	486	4.12	2.05E+00
	1931.0	2046	431	4.42	< 1.00E-01		1843.0	1651	488	3.97	5.1 OE+OO
	1932.0	2098	435	4.27	< 1.00E-01		1844.0	1643	488	4.12	4.31E+00
	1933.0	2149	441	4.27	1.90E-01		1845.0	1634	489	4.12	3.38E+00
	1934.0	2200	450	4.27	< 1.00E-01		1846.0	1625	490	4.12	7.89E+00
	1935.0	2251	472	4.42	< 1.00E-01		1847.0	1616	490	4.27	7.15E+00
	1936.0	2300	468	4.58	< 1.00E-01		1848.0	1609	490	4.27	6.55E+00
	1937.0	2345	466	4.58	< 1.00E-01		1849.0	1599	490	4.42	5.78E+00
	1938.0	2381	470	4.42	< 1.00E-01		1850.0	1586	487	4.42	1.36E+00
88	1734<0	1642	613	0.31	< 1.00E-01		1851.0	1578	486	4.42	1.18E+00
	1735.0	1631	592	1.68	< 1.00E-01		1852.0	1567	483	4.27	9.41E-01
	1736.0	1621	566	2.14	< 1.00E-01		1853.0	1552	480	4.27	6.99E-01
	1737.0	1607	539	2.59	< 1.00E-01		1854.0	1529	482	4.27	1.68E+00
	1738.0	1589	506	3.05	< 1.00E-01		1855.0	1507	483	4.27	5.87E-01
	1739.0	1570	470	3.36	< 1.00E-01		1856.0	1487	490	4.42	3.94E+00
	1740.0	1564	433	3.81	< 1.00E-01		1857.0	1468	494	4.42	2.05E+00
	1745.0	1612	399	4.12	< 1.00E-01		1858.0	1450	498	4.58	2.54E-01
	1750.0	1643	391	4.27	c 1.00E-01		1917.5	1499	462	3.97	3.00E-01
	1755.0	1665	391	4.58	c 1.00E-01		1919.0	1561	448	4.12	c 1.00E-01
	1800.0	1679	398	4.88	< 1.00E-01		1920.5	1613	436	4.42	1.57E-01
	1805.0	1688	404	5.19	< 1.00E-01		1922.0	1686	420	4.42	< 1.00E-01
	1810.0	1696	412	5.34	c 1.00E-01		1923.5	1772	408	4.73	< 1.00E-01
	1815.0	1704	420	4.58	1.25E-01		1925.0	1857	400	4.73	< 1.00E-01
	1820.0	1711	431	4.73	4.34E-01		1926.5	1940	391	4.58	< 1.00E-01
	1825.0	1719	444	4.88	6.13E-01		1928.0	2034	387	4.73	< 1.00E-01
	1830.0	1723	460	4.73	1.55E+00		1929.5	2132	389	4.58	< 1.00E-01
	1831.0	1723	464	4.73	1.59E+O0		1931.0	2221	413	4.42	< 1.00E-01
	1832.0	1718	467	4.58	2.92E+00		1932.5	2296	450	4.42	< 1.00E-01
	1833.0	1713	469	4.58	2.86E+00		1934.0	2359	458	4.27	< 1.00E-01
	1834.0	1710	472	4.42	2.82E+00		1935.5	2399	471	4.42	< 1.00E-01
	1835.0	1706	474	4.42	2.70E +00	89	1734.0	1643	603	0.61	< 1.00E-01
	1836.0	1700	476	4.42	5.1 OE+OO		1735.0	1637	576	1.98	< 1.00E-01
	1837.0	1693	477	4.27	4.70E+00		1736.0	1635	544	2.59	c 1.00E-01
	1838.0	1687	479	4.27	4.27E +00		1737.0	1629	507	3.05	< 1.00E-01
	1839.0	1682	482	4.12	3.81E+00		1738.0	1620	465	3.51	< 1.00E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
89	1739.0	1617	420	3.66	c 1.00E-01	89	1900.0	1373	520	4.58	4.61 E+00
	1740.0	1627	377	3.81	< 1.00E-01		1901.0	1347	524	4.42	2.69E +00
	1741.0	1633	360	3.81	< 1.00E-01		1915.0	1376	521	4.73	7.00E-01
	1742.0	1644	343	3.66	<1.00E-01		1916.5	1445	502	4.73	3.75E+00
	1743.0	1660	343	3.81	< 1.00E-01		1917.0	1469	494	4.58	1.49E +00
	1747.0	1722	323	4,12	< 1.00E-01		1917.5	1494	485	4.58	1.21 E+00
	1748.0	1737	297	4.27	< 1.00E-01		1918.0	1514	479	4.42	8.05E-01
	1749.0	1750	276	4.42	c 1.00E-01		1919.5	1597	454	4.27	3.23E-01
	1750.0	1764	253	4.42	< 1.00E-01		1921.0	1688	438	4.27	1.88E-01
	1755.0	1734	377	4.58	< 1.00E-01		1922.5	1770	417	4.12	c 1.00E-01
	1800.0	1729	393	4.73	< 1.00E-01		1924.0	1874	400	4.27	< 1.00E-01
	1805.0	1723	408	4.73	< 1.00E-01		1925.5	1991	396	4.27	c 1.00E-01
	1810.0	1718	417	4.88	1.11E-01		1927.0	2104	409	4.42	< 1.00E-01
	1815.0	1708	429	5.o3	3.48E-01		1928.5	2207	427	4.58	< 1.00E-01
	1820.0	1699	435	4.88	4.07E-01		1930.0	2292	455	4.58	< 1.00E-01
	1825,0	1686	441	4.73	3.95E-01		1931.5	2354	462	4.42	< 1.00E-01
	1830.0	1666	444	4.42	2.89E-01		1933.0	2407	474	4.42	< 1.00E-01
	1835.0	1644	450	4.27	1.30E-01	90	1734.0	1640	625	0.61	<1.00E-01
	1840.0	1620	462	4.27	6.71 E-01		1735.0	1642	595	2.44	< 1.00E-01
	1842.0	1606	476	4.42	3.18E+00		1736.0	1641	576	2.90	< 1.00E-01
	1843.0	1598	483	4.27	2.31 E+00		1737.0	1639	553	3.05	< 1.00E-01
	1844.0	1591	489	4.27	5.52E+00		1738.0	1637	524	3.20	c 1.00E-01
	1845.0	1583	495	4.12	3.55E+00		1739.0	1640	489	3.81	<1.00E-01
	1846.0	1573	503	4.12	7.15E+00		1740.0	1655	453	3.97	c 1.00E-01
	1847.0	1560	513	4.12	9.47E +00		1741.0	1658	441	3.97	< 1.00E-01
	1848.0	1543	527	4.27	1.36E+01		1742.0	1663	432	4.12	< 1.00E-01
	1849.0	1355	515	4.27	4.33E +00		743.0	666	421	4.12	< 1.00E-01
	1850.0	1361	507	4.27	2.53E+00		744.0	666	412	4.27	< 1.00E-01
	1851.0	1369	504	4.42	3.00E+00		745.0	668	404	4.27	<1.00E-01
	1852.0	1389	504	4.42	1.91E+00		746.0	667	402	4.27	c 1.00E-01
	1853.0	1404	504	4.42	2.91E+00		747.0	665	399	4.42	c 1.00E-01
	1854.0	1420	504	4.27	3.97E +00		1748,0	1665	397	4.42	< 1.00E-01
	1855.0	1436	503	4.42	5.00E+00		1749.0	1662	394	4.42	< 1.00E-01
	1856.0	1446	504	4.27	5.59E+00		1750.0	1663	393	4.42	< 1.00E-01
	1857.0	1427	507	4.12	4.22E+00		1751.0	1659	391	4.27	< 1.00E-01
	1858.0	1408	512	4.27	2.63E +00		1752.0	1657	390	4.42	< 1.00E-01
	1859.0	1393	516	4.42	3.61E+00		1753.0	1656	391	4.58	c 1.00E-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)	Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
90	1754.0	1653	390	4.58	< 1.00E-01	90	1832.0	1597	487	4.27	1.90E+O0
	1755.0	1650	390	4.58	< 1.00E-01		1833.0	1593	491	4.27	5.27E + 00
	1756.0	1647	389	4.42	c 1.00E-01		1834.0	1589	494	4.27	4.44E+00
	1757.0	1647	390	4.58	< 1.00E-01		1835.0	1583	496	4.27	3.54E+00
	1758.0	1645	390	4.58	< 1.00E-01		1636.0	1578	497	4.27	2.94E+00
	1759.0	1643	391	4.73	< 1.00E-01		1837.0	1571	500	4.12	1.87E+00
	1800.0	1642	392	4.73	< 1.00E-01		1838.0	1567	501	4.12	7.26E + 00
	1801.0	1639	390	4.73	< 1.00E-01		1839.0	1556	505	3.97	4.28E + 00
	1802,0	1637	391	4.73	< 1.00E-01		1840.0	1552	506	3.97	3.33E+00
	1803.0	1636	393	4.88	< 1.00E-01		1841.0	1546	508	3.97	9.64E + 00
	1804.0	1635	394	4.88	< 1.00E-01		1842.0	1541	509	4.12	8.35E +00
	1805.0	1634	395	4.88	< 1.00E-01		1843.0	1536	510	4.12	7.14E+00
	1806.0	1632	397	4.73	< 1.00E-01		1844.0	1529	511	4.27	5.65E+00
	1807.0	1627	397	4.73	< 1.00E-01		1845.0	1524	512	4.12	4.55E+00
	1808.0	1624	398	4.58	<1.00E-01		1846.0	1519	512	4.12	3.35E+ 00
	1809.0	1624	403	4.58	c 1.00E-01		1847.0	1512	513	4.27	9.52E +00
	1810.0	1624	405	4.73	c 1.00E-01		1848.0	1507	515	4.42	7.72E+00
	1811.0	1622	408	4.73	< 1.00E-01		1849.0	1501	516	4.27	6.14E+00
	1812.0	1619	410	4.73	< 1.00E-01		1850.0	1493	517	4.27	1.19E+01
	1813.0	1618	414	4.88	< 1.00E-01		1851.0	1484	517	4.27	9.96E + 00
	1814.0	1617	417	5.03	< 1.00E-01		1852.0	1476	519	4.12	7.71E+00
	1815.0	1617	421	4.88	< 1.00E-01		1854.0	1458	520	4.12	3.79E+00
	1816.0	1616	424	4.88	< 1.00E-01		1855.0	1446	521	4.12	8.05E +00
	1818.0	1614	432	4.73	1.99E-01		1856.0	1431	521	4.12	6.70E +00
	1819.0	1612	437	4.58	1.98E-01		1857.0	1416	521	4.27	5.06E+00
	1820.0	1611	441	4.58	2.01 E-01		1858.0	1407	523	4.42	3.69E+00
	1821.0	1611	444	4.58	2.03E-01		1859.0	1386	524	4.58	1.47E +00
	1822.0	1610	447	4.42	2.05E-01		1900.0	1370	525	4.58	3.82E + 00
	1823.0	1610	451	4.42	6.12E-01		1901.0	1344	525	4.42	2.41E+00
	1824.0	1610	454	4.58	5.95E-01		1915.5	1360	492	4.73	8.31 E-01
	1825.0	1609	457	4.58	5.75E-01		1917.0	1411	481	4.88	4.73E-01
	1826.0	1608	462	4.58	5.33E-01		1918.5	1455	476	4.73	4.70E-01
	1827.0	1608	467	4.58	1.38E+O0		1920.0	1493	473	4.42	5.31 E-01
	1828.0	1607	472	4.42	1.18E+00		1921.5	1544	466	4.58	8.13E-01
	1829.0	1605	476	4.42	3.09E+00		1923.0	1594	466	4.42	7.24E-01
	1830.0	1592	476	4.42	2.65E+00		1924.5	1644	444	4.27	< 1.00E-01
	1831.0	1601	483	4.42	2.38E +00		1926.0	1703	435	4.27	2.1 OE-01

Appendix D-6

Continued

Fish No.	Time	x (m)	Y (m)	Depth (m)	Cone (ppb)
90	1927.5	1785	431	4.42	1.88E-01
	1929.0	1892	438	4.73	c 1.00E-01
	1930.5	1970	443	4.58	< 1.00E-01
	1932.0	2034	449	4.42	< 1.00E-01
	1933.5	2102	454	4.88	3.76E-01
	1936.5	2256	471	4.73	c 1.00E-01

APPENDIX E

APPENDIX E

CONCENTRATIONS ($\mu g/L$) OF INDIVIDUAL HYDROCARBON COMPONENTS DETECTED IN 94 SAMPLES COLLECTED IN JAKOLOF BAY

KASITSNA BAY BACKGROUND WATER SAMPLES

WATER SAMPLE #	1	2	3	4
HYDROCARBON:				
Methane	0.16	0.14	0.07	0.13
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	0.05	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	1.10	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	0.16	1.12	N.D.
Octanes or cycloheptanes	N.D.	N.D.	0.15	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.32	0.30	1.33	0.13
Total w/o C1-C4	1.10	0.16	1.27	0.00

KASITSNA BAY BACKGROUND WATER SAMPLES

WATER SAMPLE #	5
HYDROCARBON:	
Methane	0.07
Ethane	N.D.
Propane	N.D.
Isobutane	N.D.
n-Butane	N.D.
Isopentane	N.D.
n-Pentane	N.D.
2,2-Dimethylbutane	N.D.
Cyclopentane + 2-Methylpentane	N.D.
3-Methylpentane	N.D.
n-Hexane	N.D.
Methylcyclopentane	N.D.
Benzene	N.D.
Cyclohexane	N.D.
n-Heptane	N.D.
Methylcyclohexane	N.D.
Toluene	N.D.
Octanes or cycloheptanes	N.D.
Octanes or cycloheptanes	N.D.
Octanes or cycloheptanes	N.D.
Octanes or cycloheptanes	N.D.
Octanes or cycloheptanes	N.D.
Ethylbenzene	N.D.
m-, p-Xylene	N.D.
o-Xylene	N.D.
Isopropylbenzene	N.D.
C3 Benzenes	N.D.
o-Methylethylbenzene	N.D.
1,2,4-Trimethylbenzene	N.D.
1,2,3-Trimethylbenzene	N.D.

Total Hydrocarbons	0.07
Total w/o C1-C4	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	6	7	8	9
HYDROCARBON:				
Methane	0.30	0.32	0.33	0.33
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	0.15	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.77	1.51	0.52	0.73
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.06	1.99	0.85	1.07
Total w/o C1-C4	0.77	1.66	0.52	0.73

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	10	11	12	13
HYDROCARBON:				
Methane	0.25	0.33	0.34	0.23
Ethane	N.D.	0.12	N.D.	N.D.
Propane	N.D.	0.19	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	0.43	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.67	1.78	1.02	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	0.92	2.85	1.36	0.23
Total w/o C1-C4	0.67	2.20	1.02	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	14	15	16	17
HYDROCARBON:				
Methane	0.21	0.29	0.27	0.27
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	8.23	0.30	0.46
n-Pentane	N.D.	9.98	0.14	0.56
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	0.61	N.D.	0.08
3-Methylpentane	N.D.	0.09	N.D.	N.D.
n-Hexane	N.D.	0.20	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	17.24	N.D.	0.98
Cyclohexane	N.D.	1.44	N.D.	N.D.
n-Heptane	N.D.	0.57	N.D.	N.D.
Methylcyclohexane	N.D.	0.79	N.D.	N.D.
Toluene	1.32	13.19	1.15	1.08
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	4.67	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.53	57.31	1.86	3.43
Total u/o C1-C4	1.32	57.02	1.59	3.16

8

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	18	19	20	21
HYDROCARBON:				
Methane	0.28	0.30	*	0.28
Ethane	N.D.	N.D.		N.D.
Propane	N.D.	N.D.		N.D.
Isobutane	N.D.	N.D.		N.D.
n-Butane	N.D.	N.D.		N.D.
Isopentane	N.D.	N.D.		1.58
n-Pentane	0.07	N.D.		1.93
2,2-Dimethylbutane	N.D.	N.D.		N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.		0.21
3-Methylpentane	N.D.	N.D.		N.D.
n-Hexane	N.D.	N.D.		N.D.
Methylcyclopentane	0.16	N.D.		N.D.
Benzene	N.D.	N.D.		3.58
Cyclohexane	N.D.	N.D.		0.30
n-Heptane	N.D.	N.D.		N.D.
Methylcyclohexane	N.D.	N.D.		0.39
Toluene	2.61	0.75		5.37
Octanes or cycloheptanes	N.D.	N.D.		N.D.
Octanes or cycloheptanes	N.D.	N.D.		N.D.
Octanes or cycloheptanes	N.D.	N.D.		N.D.
Octanes or cycloheptanes	N.D.	N.D.		N.D.
Octanes or cycloheptanes	N.D.	N.D.		N.D.
Ethylbenzene	N.D.	N.D.		N.D.
m-, p-Xylene	N.D.	N.D.		1.58
o-Xylene	N.D.	N.D.		N.D.
Isopropylbenzene	N.D.	N.D.		N.D.
C3 Benzenes	N.D.	N.D.		N.D.
o-Methylethylbenzene	N.D.	N.D.		N.D.
1 ,2,4-Trimethylbenzene	N.D.	N.D.		N.D.
l,2,3-Trimethylbenzene	N.D.	N.D.		N.D.
Total Hydrocarbons	3.12	1.05	0.00	15.20
Total w/o C1-C4	2.84	0.75	0.00	14.93

* SAMPLE BOTTLE BROKEN

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	22	23	24	25
HYDROCARBON:				
Methane	0.38	0.28	0.29	*
Ethane	N.D.	N.D.	N.D.	
Propane	N.D.	N.D.	N.D.	
Isobutane	N.D.	N.D.	N.D.	
n-Butane	N.D.	N.D.	N.D.	
Isopentane	1.06	6.18	N.D.	
n-Pentane	0.14	7.27	0.09	
2,2-Dimethylbutane	N.D.	N.D.	N.D.	
Cyclopentane + 2-Methylpentane	N.D.	0.78	N.D.	
3-Methylpentane	N.D.	0.09	N.D.	
n-Hexane	N.D.	0.19	N.D.	
Methylcyclopentane	N.D.	N.D.	N.D.	
Benzene	N.D.	11.39	N.D.	
Cyclohexane	N.D.	1.05	N.D.	
n-Heptane	N.D.	0.60	N.D.	
Methylcyclohexane	N.D.	0.71	N.D.	
Toluene	N.D.	12.56	1.44	
Octanes or cycloheptanes	N.D.	N.D.	N.D.	
Octanes or cycloheptanes	N.D.	N.D.	N.D.	
Octanes or cycloheptanes	N.D.	N.D.	N.D.	
Octanes or cycloheptanes	N.D.	N.D.	N.D.	
Octanes or cycloheptanes	N.D.	N.D.	N.D.	
Ethylbenzene	N.D.	N.D.	N.D.	
m-, p-Xylene	N.D.	2.95	N.D.	
o-Xylene	N.D.	N.D.	N.D.	
Isopropylbenzene	N.D.	N.D.	N.D.	
C3 Benzenes	N.D.	N.D.	N.D.	
o-Methylethylbenzene	N.D.	N.D.	N.D.	
l,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	
l,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	
Total Hydrocarbons	1.58	44.06	1.82	0.00
Total w/o C1-C4	1.20	43.'78	1.53	0.00

* SAMPLE BOTTLE BROKEN

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	26	27(1)	27(2)
HYDROCARBON:			
Methane	0.32	0.30	0,31
Ethane	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.
Isopentane	0.17	N.D.	N.D.
n-Pentane	0.18	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.
n-Heptane	0.18	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.
Toluene	0.61	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.
m-, p-Xylene	0.65	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.
C3 Benzenes	6.79	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.
	-------	..S--.-	-------
Total Hydrocarbons	8.90	0.30	0.31
Total w/o C1-C4	8.58	0.00	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	28	29	30	31
HYDROCARBON:	*	*	*	
Methane				0.17
Ethane				N.D.
Propane				N.D.
Isobutane				N.D.
n-Butane				N.D.
Isopentane				N.D.
n-Pentane				N.D.
2,2-Dimethylbutane				N.D.
Cyclopentane + 2-Methylpentane				N.D.
3-Methylpentane				N.D.
n-Hexane				N.D.
Methylcyclopentane				N.D.
Benzene				N.D..
Cyclohexane				N.D.
n-Heptane				N.D.
Methylcyclohexane				N.D.
Toluene				N.D.
Octanes or cycloheptanes				N.D.
Octanes or cycloheptanes				N.D.
Octanes or cycloheptanes				N.D.
Octanes or cycloheptanes				N.D.
Octanes or cycloheptanes				N.D.
Ethylbenzene				N.D.
m-, p-Xylene				N.D.
o-Xylene				N.D.
Isopropylbenzene				N.D.
C3 Benzenes				N.D.
o-Methylethylbenzene				N.D.
1,2,4-Trimethylbenzene				N.D.
1,2,3-Trimethylbenzene				N.D.
Total Hydrocarbons	0.00	0.00	0.00	0.17
Total w/o C1-C4	0.00	0.00	0.00	0.00

* SAMPLES MISSING

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	32	33	34	35
HYDROCARBON:				
Methane	*	0.08	*	*
Ethane		N.D.		
Propane		N.D.		
Isobutane		N.D.		
n-Butane		N.D.		
Isopentane		N.D.		
n-Pentane		N.D.		
2,2-Dimethylbutane		N.D.		
Cyclopentane + 2-Methylpentane		N.D.		
3-Methylpentane		N.D.		
n-Hexane		N.D.		
Methylcyclopentane		N.D.		
Benzene		N.D.		
Cyclohexane		N.D.		
n-Heptane		N.D.		
Methylcyclohexane		N.D.		
Toluene		N.D.		
Octanes or cycloheptanes		N.D.		
Octanes or cycloheptanes		N.D.		
Octanes or cycloheptanes		N.D.		
Octanes or cycloheptanes		N.D.		
Octanes or cycloheptanes		N.D.		
Ethylbenzene		N.D.		
m-, p-Xylene		N.D.		
o-Xylene		N.D.		
Isopropylbenzene		N.D.		
C3 Benzenes		N.D.		
o-Methylethylbenzene		N.D.		
1 ,2,4-Trimethylbenzene		N.D.		
1,2,3-Trimethylbenzene		N.D.		
Total Hydrocarbons	0.00	0.08	0.00	0.00
Total w/o C1-C4	0.00	0.00	0.00	0.00

* SAMPLES MISSING

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	36	37	38	39
HYDROCARBON:				
Methane	0.38	0.26	0.29	0.32
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.96	1.15	N.D.	1.43
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
l,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.34	1.42	0.29	1.75
Total w/o C1-C4	0.96	1.15	0.00	1.43

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	40	41	42	43
HYDROCARBON:				
Methane	0.26	0.36	0.35	0.33
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
l,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
	-------	-------	-------	-------
Total Hydrocarbons	0.26	0.36	0,35	0.33
Total w/o C1-C4	0.00	0.00	0.00	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	44	45	46	47
HYDROCARBON:				
Methane	0.26	0.40	0.28	0.31
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	10.72
n-Pentane	N.D.	N.D.	N.D.	13.75
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	1.23
3-Methylpentane	N.D.	N.D.	N.D.	0.12
n-Hexane	N.D.	N.D.	N.D.	0.28
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	17.94
Cyclohexane	N.D.	N.D.	N.D.	1.89
n-Heptane	N.D.	N.D.	N.D.	0.83
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	N.D.	1.01	N.D.	16.11
Octanes or cycloheptanes	N.D.	N.D.	N.D.	0.93
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	1.10
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	0.26	1.41	0.28	65.22
Total w/o C1-C4	0.00	1.01	0.00	64.91

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	48	49	50	51
HYDROCARBON:				
Methane	0.30	0.40	0.30	0.39
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	2.52	0.97	2.35	0.67
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	2.82	1.37	2.65	1.06
Total w/o C1-C4	2.52	0.97	2.35	0.67

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	52	53	54	55
HYDROCARBON:				
Methane	0.32	0.30	0.31	0.36
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	2.01	0.48	0.81	0.92
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	2.34	0.78	1.12	1.27
Total w/o C1-C4	2.01	0.48	0.81	0.92

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	56	57	58	59
HYDROCARBON:				
Methane	0.32	0.32	0.10	0.15
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	8.07	1.29	N.D.	N.D.
n-Pentane	9*53	1.53	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	1.09	0.21	0.09	0 0,5
3-Methylpentane	0.09	N.D.	N.D.	N.D.
n-Hexane	0.23	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	15.54	3.25	22.28	20.68
Cyclohexane	1.54	N.D.	N.D.	N.D.
n-Heptane	0.56	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	11.29	2.33	22.30	4.85
Octanes or cycloheptanes	0.33	N.D.	0.77	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	2.35	N.D.	1.60	N.D.
m-, p-Xylene	2.86	1.38	2.45	4.42
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	53.80	10.31	49.59	30.25
Total w/o C1-C4	53.48	9999	49.49	30.10

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	60	61	62	63
HYDROCARBON:				
Methane	0.32	0.27	0.27	0.25
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	N.D.	6.82	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	0.32	7.08	0.27	0.25
Total w/o C1-C4	0.00	6.82	0.00	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	64	65	66	67
HYDROCARBON:				
Methane	0.25	0.25	0.34	0.26
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.76	0.88	0.59	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.01	1.13	0.93	0.26
Total w/o C1-C4	0.76	0.88	0.59	0.00

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	68	69	70	71
HYDROCARBON:				
Methane	0.27	N.D.	0.29	0.30
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.91	N.D.	N.D.	1.81
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.18	0.00	0.29	2.11
Total w/o C1-C4	0.91	0.00	0.00	1.81

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	72	73	74	75
HYDROCARBON:				
Methane	0.60	0.28	0.20	0.29
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	N.D.
n-Pentane	N.D.	N.D.	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.98	1.93	1.53	0.93
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.58	2.21	1.73	1.22
Total w/o C1-C4	0.98	1.93	1.53	0.93

1

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	76	77	78	79
HYDROCARBON:				
Methane	0.31	0*30	0.13	0.19
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	0.33	N.D.	N.D.
n-Pentane	N.D.	0.33	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	0.12	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	0061	N.D.	N.D.
Cyclohexane	N.D.	N.D.	N.D.	N.D.
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	0.57	2.37	1.16	0.61
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1 ,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	0.88	4.06	1.29	0.80
Total w/o C1-C4	0.57	3.76	1.16	0.61

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	80	81	82	83
HYDROCARBON:				
Methane	0.22	0.25	0.37	0.19
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	N.D.	N.D.	N.D.	2.07
n-Pentane	N.D.	N.D.	N.D.	2.51
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.	N.D.	0,35
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	N.D.	N.D.	N.D.	6.46
Cyclohexane	N.D.	N.D.	N.D.	0.47
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	1.09	1.49	N.D.	7.48
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	2.52
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	1.31	1.73	0.37	22.04
Total w/o C1-C4	1.09	1.49	0.00	21.85

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	84	85	86	87
HYDROCARBON:				
Methane	0.30	0.38	0.61	0.34
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	3*99	0.86	N.D.	1.02
n-Pentane	4.78	1.07	N.D.	1.05
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	1.94	1.49	N.D.	0.15
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	0.11	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	6.90	2.64	N.D.	2.04
Cyclohexane	0.71	N.D.	N.D.	N.D.
n-Heptane	0.39	N.D.	N.D.	N.D.
Methylcyclohexane	0.29	N.D.	N.D.	N.D.
Toluene	4.08	1.53	0.60	1.41
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes *or* cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	1.42	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
l,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	24.91	7.98	1.20	6.02
Total w/o C1-C4	24.60	7.59	0.60	5.68

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	88	89	90	91
HYDROCARBON:				
Methane	00_31	0.35	0.31	0.30
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	N.D.	N.D.	N.D.	N.D.
n-Butane	N.D.	N.D.	N.D.	N.D.
Isopentane	1.22	0.82	0.46	0.19
n-Pentane	1.25	0.82	0.38	0.22
2,2-Dimethylbutane	N.D.	N.D.	N.D.	N.D.
Cyclopentane + 2-Methylpentane	0.20	0.13	N.D.	N.D.
3-Methylpentane	N.D.	N.D.	N.D.	N.D.
n-Hexane	N.D.	N.D.	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.	N.D.	N.D.
Benzene	2.54	2.50	0.52	N.D.
Cyclohexane	N.D.	N.D.	N.D.	0.47
n-Heptane	N.D.	N.D.	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.	N.D.	N.D.
Toluene	1.64	1.40	0.77	3.29
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	N.D.	N.D.	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.	N.D.	N.D.
o-Xylene	N.D.	N.D.	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.	N.D.	N.D.
C3 Benzenes	N.D.	N.D.	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
Total Hydrocarbons	7.17	6.02	2.44	4.46
Total w/o C1-C4	6.85	5.68	2.14	4.16

KASITSNA BAY WATER SAMPLES

WATER SAMPLE #	92	93
HYDROCARBON:		
Methane	0.30	0.28
Ethane	N.D.	N.D.
Propane	N.D.	N.D.
Isobutane	N.D.	N.D.
n-Butane	N.D.	N.D.
Isopentane	0.34	N.D.
n-Pentane	0.24	N.D.
2,2-Dimethylbutane	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.
3-Methylpentane	N.D.	N.D.
n-Hexane	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.
Benzene	0.85	N.D.
Cyclohexane	N.D.	N.D.
n-Heptane	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.
Toluene	3.18	1.44
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Ethylbenzene	N.D.	N.D.
m-, p-Xylene	N.D.	N.D.
o-Xylene	N.D.	N.D.
Isopropylbenzene	N.D.	N.D.
C3 Benzenes	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.
	-------	-------
Total Hydrocarbons	4.91	1.73
Total w/o C1-C4	4.61	1.44

APPENDIX F

APPENDIX F

WATER-SOLUBLE HYDROCARBONS FROM REGULAR GASOLINE

REGULAR GASOLINE SAMPLES

DILUTION FACTOR	**NO DILUTION	0.10	0.01	.005
HYDROCARBON:				
Methane	1.30	2.94	3.62	2.70
Ethane	N.D.	N.D.	N.D.	N.D.
Propane	N.D.	N.D.	N.D.	N.D.
Isobutane	3.30	0.33	N.D.	N.D.
n-Butane	34.80	3.48	0.45	0.32
Isopentane	39.90	3*99	0.24	0.08
n-Pentane	57*7O	5077	0.23	N.D.
2,2-Dimethylbutane	6.10	0.61	N.D.	N.D.
Cyclopentane + 2-Methylpentane	60.50	6.05	0.39	0.64
3-Methylpentane	36.20	3.62	0.15	N.D.
n-Hexane	42.80	4.28	N.D.	N.D.
Methylcyclopentane	93.10	9.31	0.42	0.19
Benzene	491.90	49.19	11.18	1.37
Cyclohexane	89.50	8.95	N.D.	N.D.
n-Heptane	86.20	8.62	N.D.	N.D.
Methylcyclohexane	68.20	6.82	N.D.	N.D.
Toluene	2253.10	225.31	16.37	5.07
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ott nes o cycloheptanes	N.D.	N.D.	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.	N.D.	N.D.
Ethylbenzene	193.60	19 36	N.D.	N.D.
m-, p-Xylene	1036.90	103.69	9.80	3*99
o-Xylene	451..70	45.17	3.32	1.39
Isopropylbenzene	9.50	0.95	N.D.	N.D.
C3 Benzenes	333.90	33.39	3.45	1.05
o-Methylethylbenzene	65.30	6.53	N.D.	N.D.
l,2,4-Trimethylbenzene	269.00	26.90	1.92	3.66
1,2,3-Trimethylbenzene	N.D.	N.D.	N.D.	N.D.
	-------	------	-------	-------
Total Hydrocarbons	5724.50	575.26	51.54	20.46
Total w/o C1-C4	5685.10	568.51	47.47	17.44

**1 drop of gasoline in approx. 200 ml water

REGULAR GASOLINE SAMPLES

DILUTION FACTOR	.0025	.0013
HYDROCARBON:		
Methane	3.06	3.02
Ethane	N.D.	N.D.
Propane	N.D.	N.D.
Isobutane	N.D.	N.D.
n-Butane	0.22	N.D.
Isopentane	N.D.	N.D.
n-Pentane	N.D.	N.D.
2,2-Dimethylbutane	N.D.	N.D.
Cyclopentane + 2-Methylpentane	N.D.	N.D.
3-Methylpentane	N.D.	N.D.
n-Hexane	N.D.	N.D.
Methylcyclopentane	N.D.	N.D.
Benzene	1.23	0.77
Cyclohexane	N.D.	N.D.
n-Heptane	N.D.	N.D.
Methylcyclohexane	N.D.	N.D.
Toluene	1.05	1.59
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Octanes or cycloheptanes	N.D.	N.D.
Ethylbenzene	N.D.	N.D.
m-, p-Xylene	2.01	0.92
o-Xylene	0.70	N.D.
Isopropylbenzene	N.D.	N.D.
C3 Benzenes	N.D.	N.D.
o-Methylethylbenzene	N.D.	N.D.
1,2,4-Trimethylbenzene	N.D.	N.D.
1,2,3-Trimethylbenzene	N.D.	N.D.
	------	------
Total Hydrocarbons	8.27	6.30
Total w/o C1-C4	4.99	3.28

APPENDIX G

Appendix G

RESULTS OF ANALYSIS OF VARIANCE TESTS

Variable Tested	Factor	Degrees of Freedom	F Ratio	Signif- icance
Total Hydrocarbon Concentration	Background and Control Experiments (Sample Nos. 1-12,27-43, 60-71)	2, 32	0.89	0.41
Fish Depth	All Six Experiments	5, 1263	329.8	0.00[a]
Duration-of-Return	Treatment 1 vs Control 1	1, 12	0.94	0.34
Duration-of-Return	Treatment 2 vs Control 2	1, 12	0.14	0.71
Duration-of-Return	Treatment 3 vs Control 3	1, 34	161.2	0.00
Swim Speed	Time Periods before, during, and after exposure to hydrocarbon concentrations >1 ppb for Treatment 3	2, 799	600.9	0.00

[a] Results of Multiple Range Test indicated differences among Treatments (T) and Controls (C) are as follows:

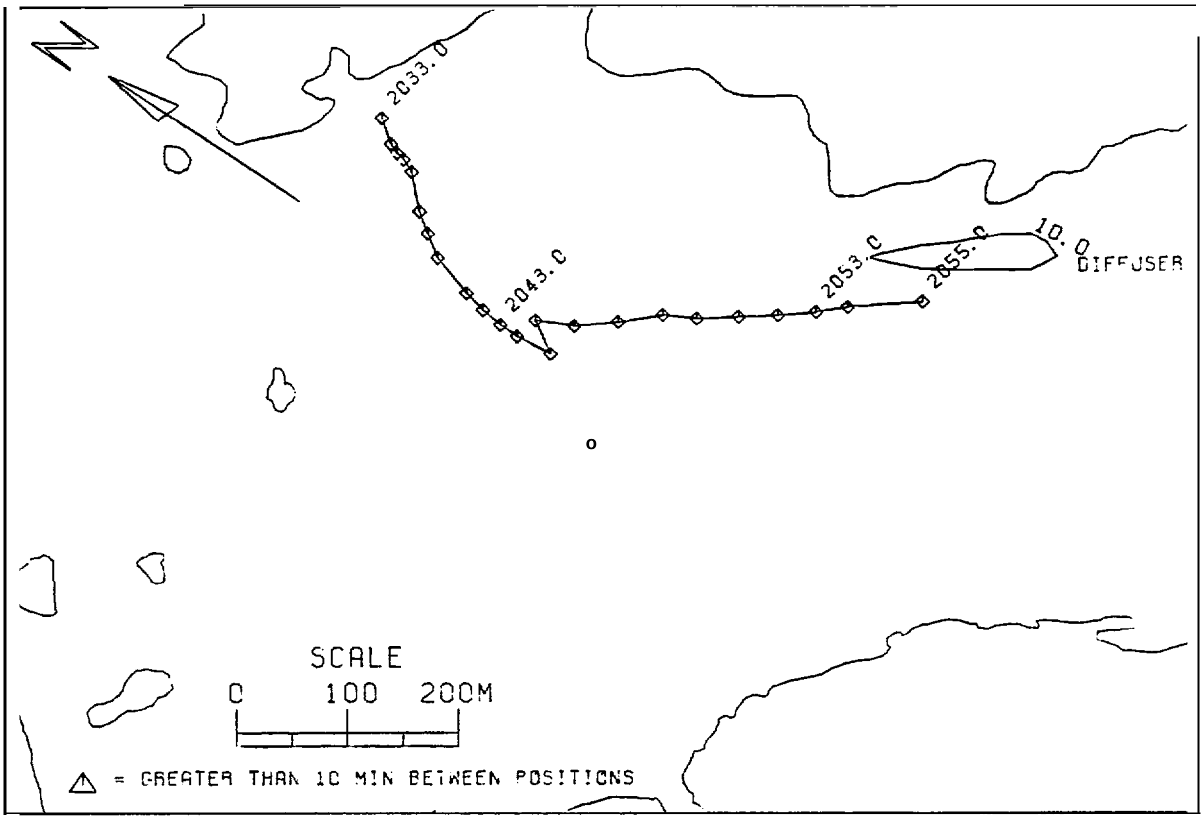
C3 T2 TI cl C2 T3

Experiments not connected by an underline are significantly (P <0.05) different, those connected by an underline are not significantly different.

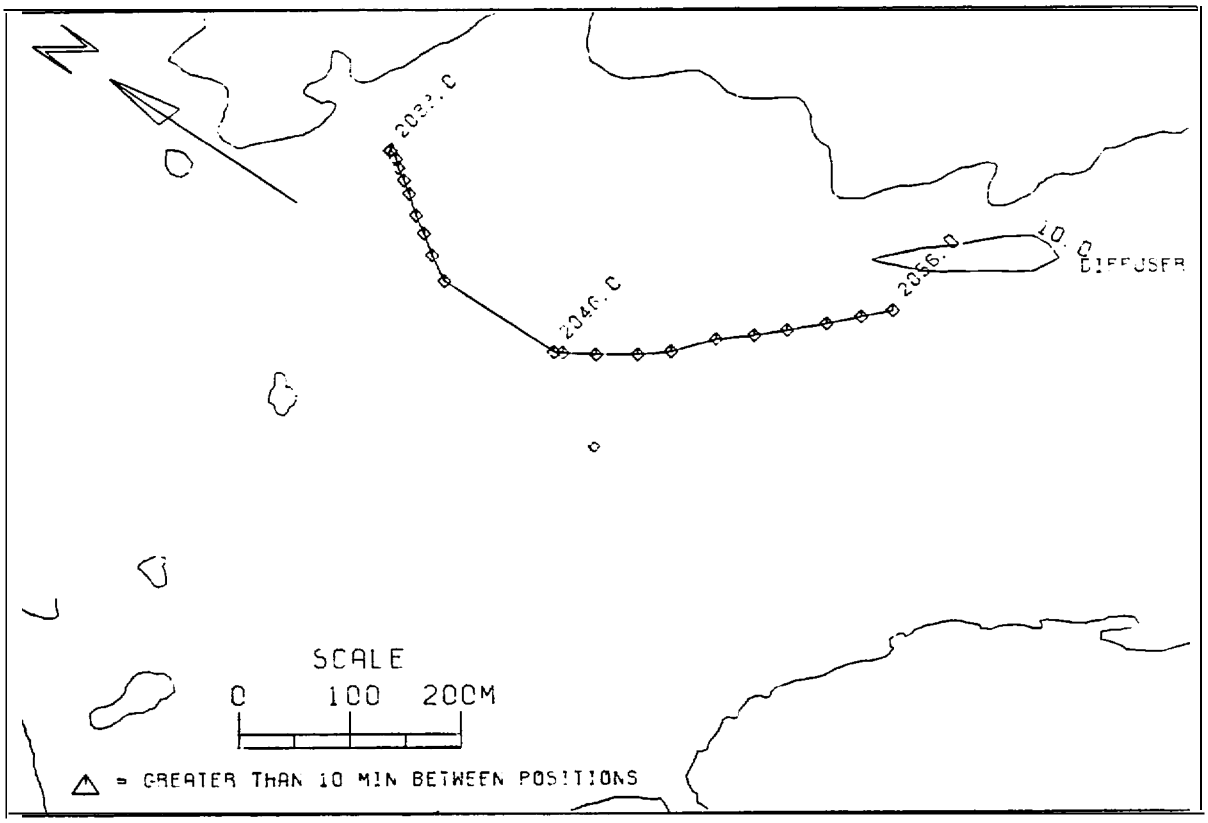
APPENDIX H

APPENDIX H

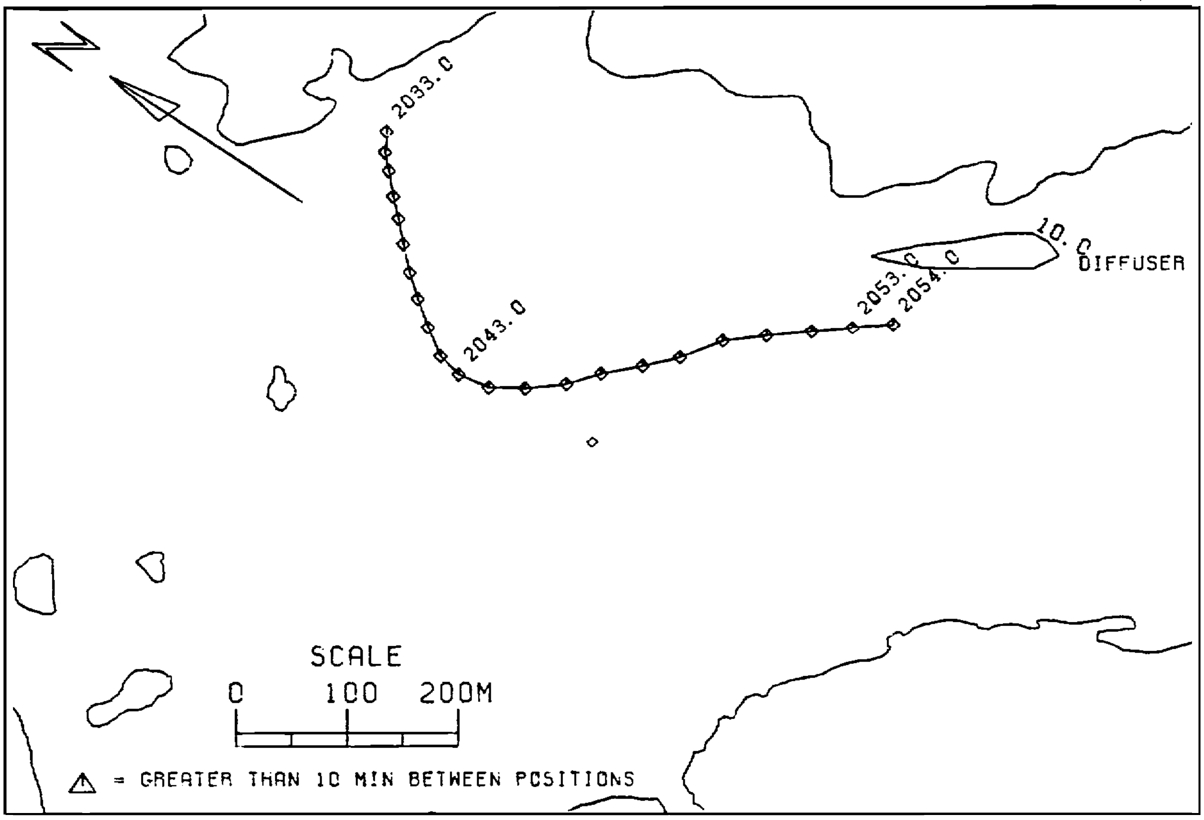
PLOTS OF HORIZONTAL MOVEMENTS OF ADULT PINK SALMON DURING CONTROL EXPERIMENTS



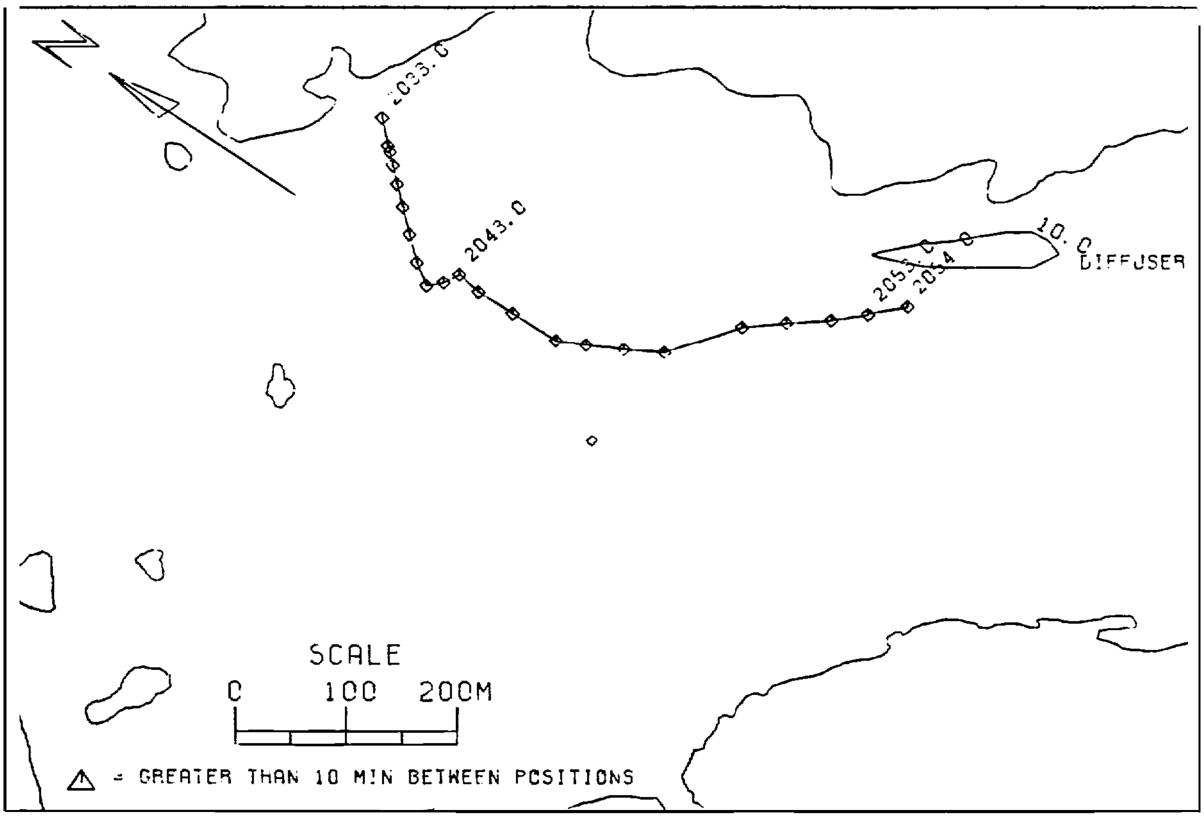
JAKOLOF B AY, FISH 03, CONTROL NO. 1, 7/19/88



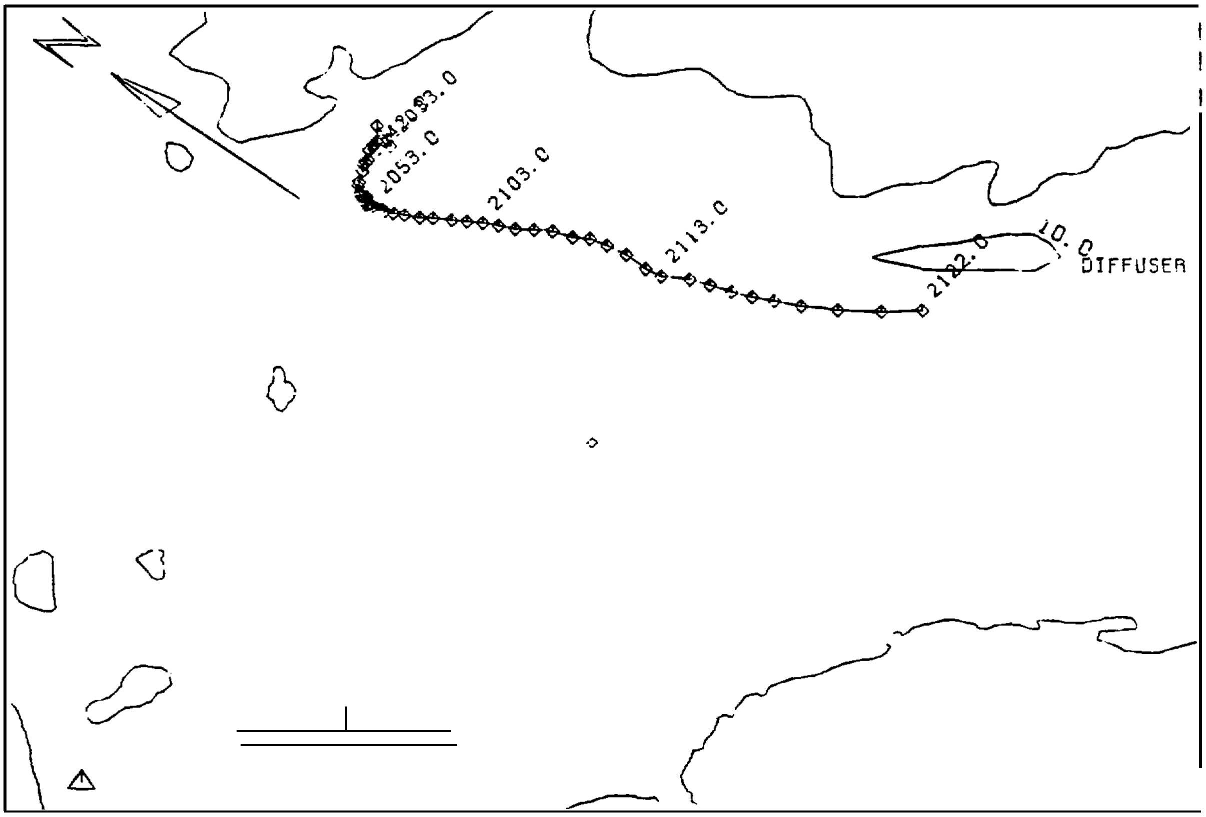
JAKOLOF BAY, FISH 04. CONTROL NO. 1, 7/19/88



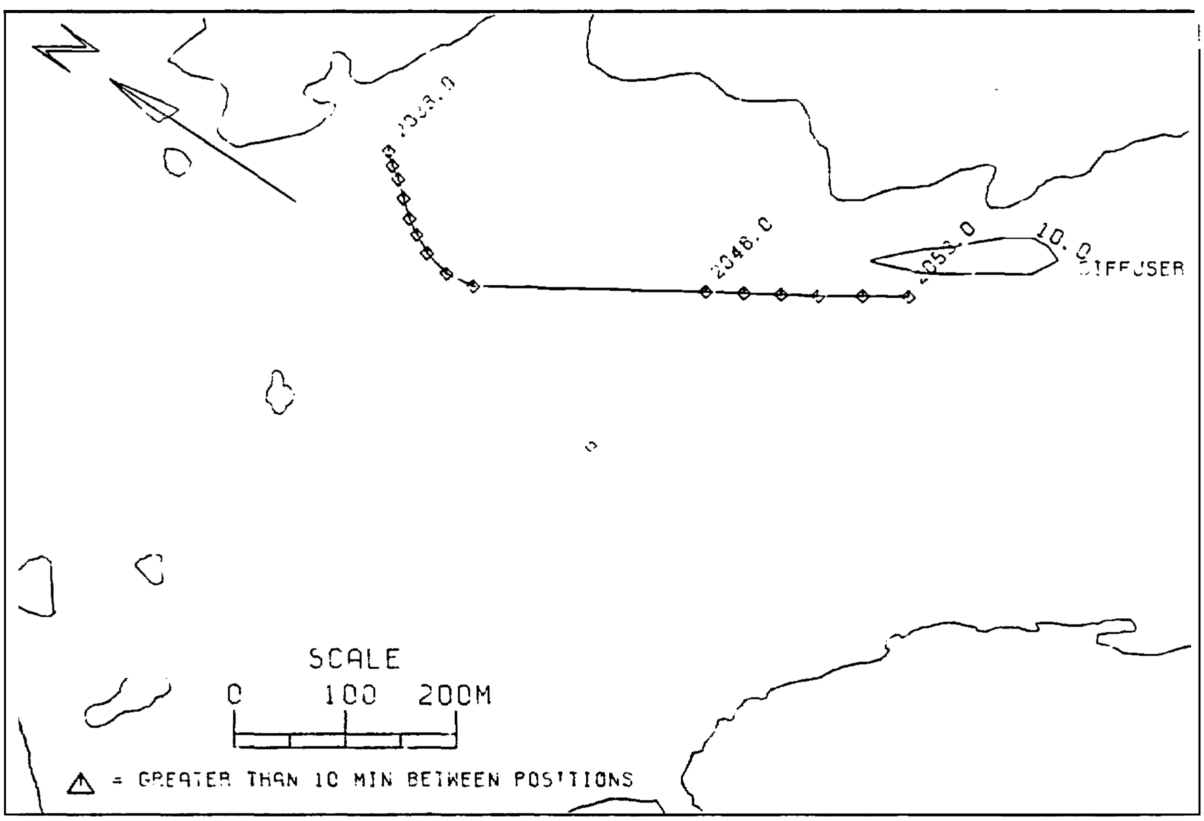
JAKOLOF BAY, FISH 05, CONTROL NO. 1, 7/'19/88



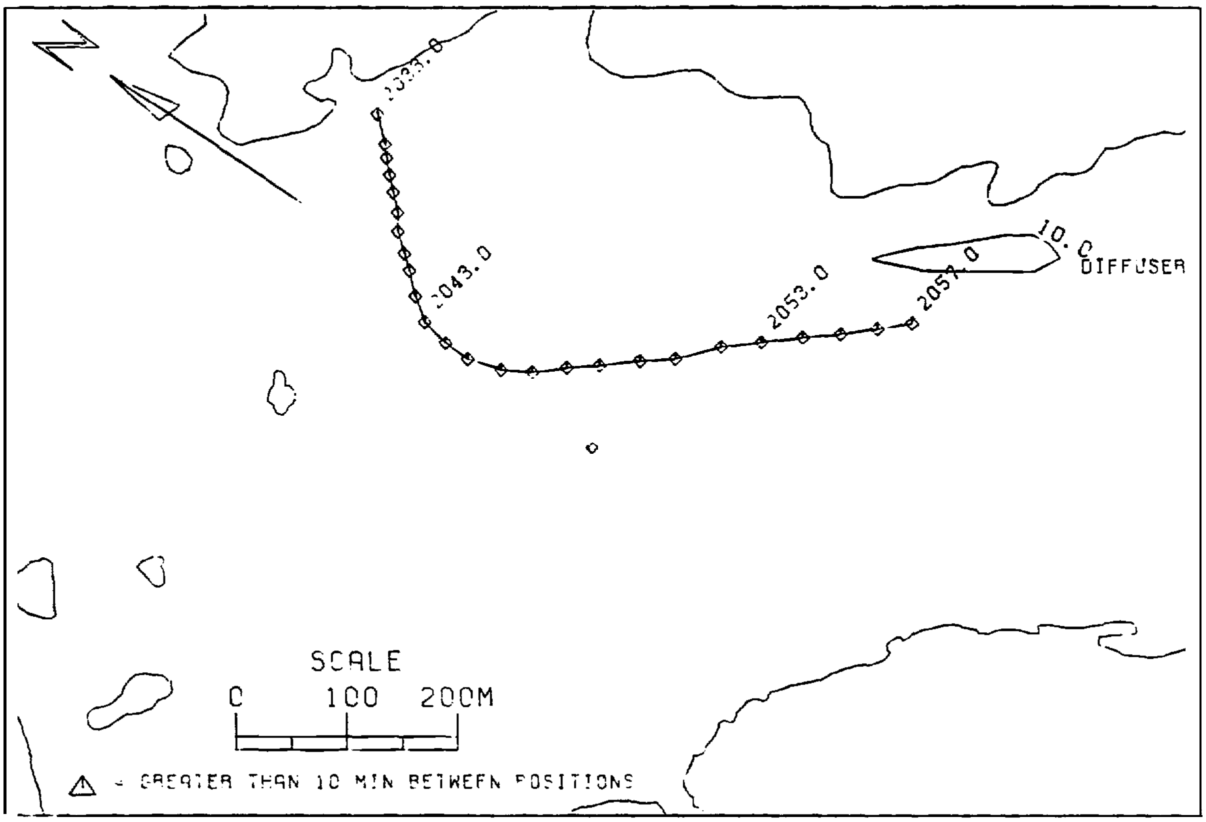
JAKOLOF BAY, FISH 06, CONTROL NO. 1, 7/19/88



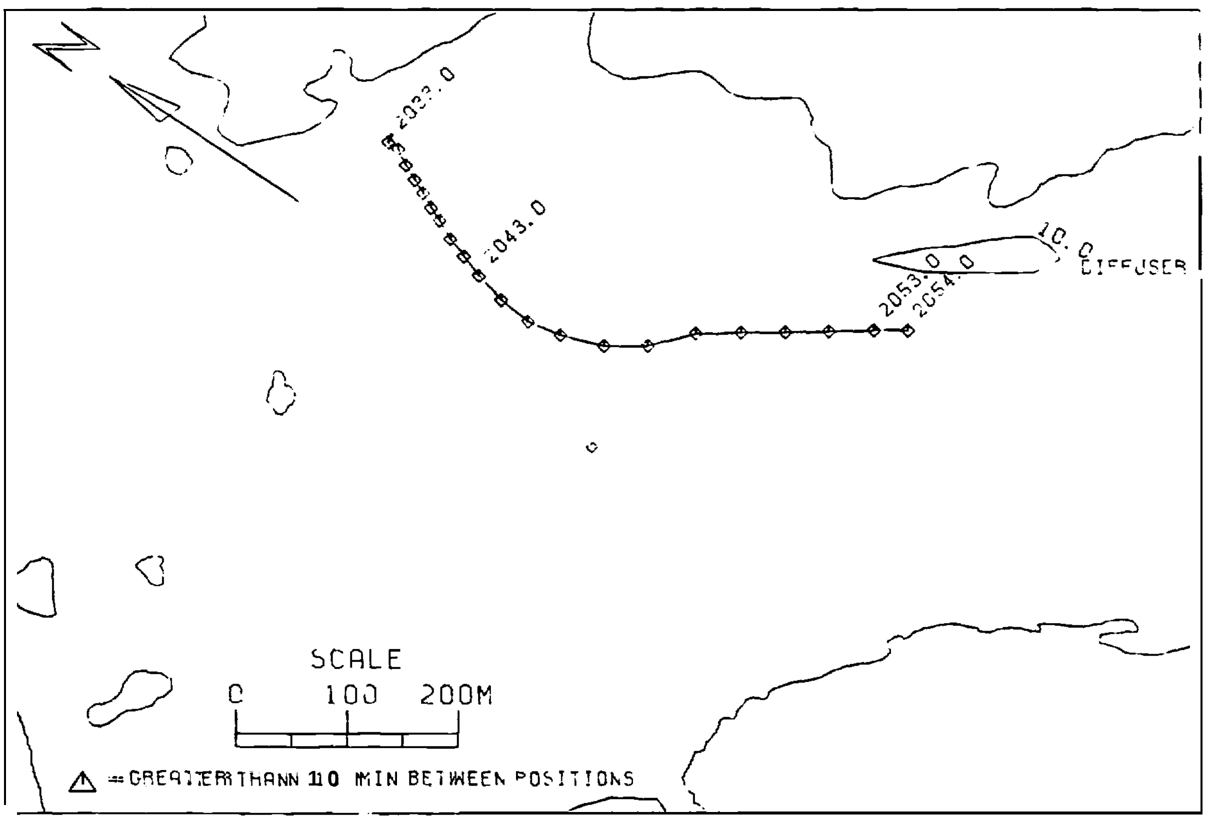
JAKOLOF BAY, FISH 07, CONTROL NO. 1, 7/19/88



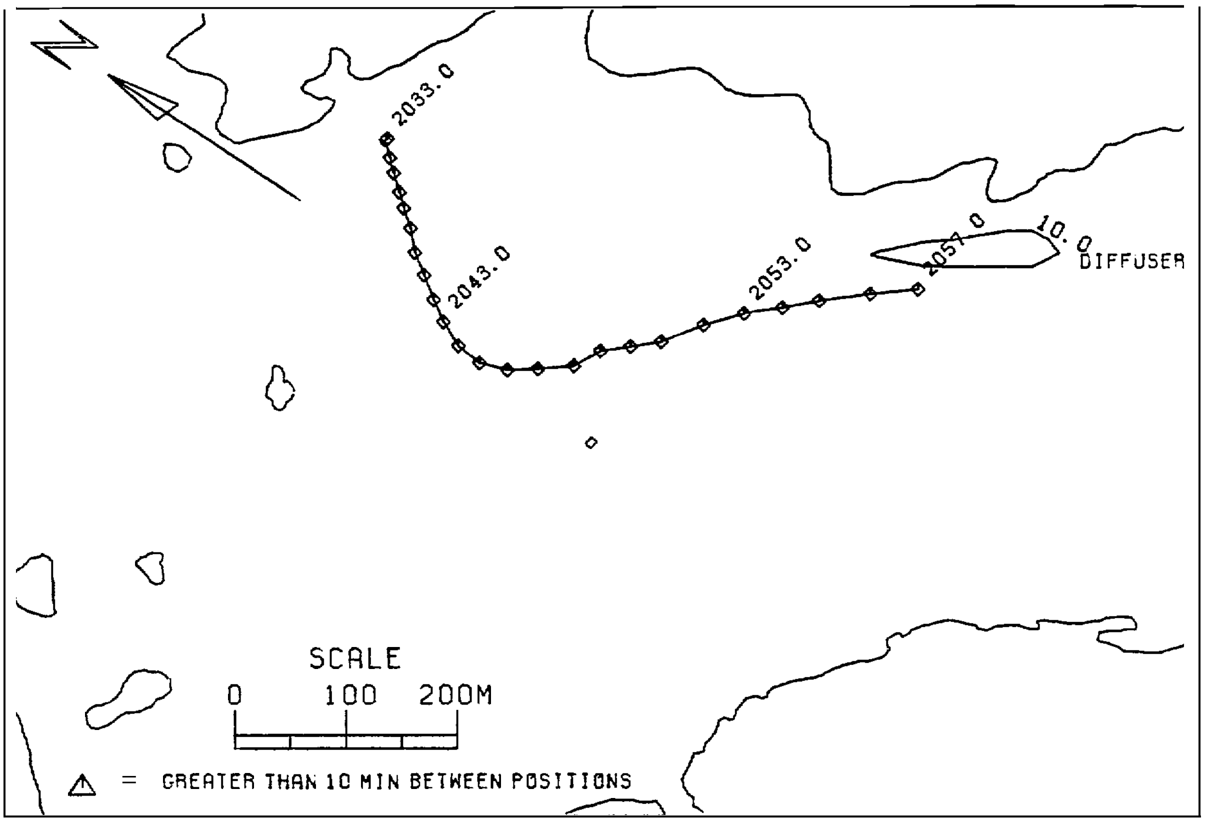
JAKOLOF BAY, FISH 08, CONTROL NO. 1, 7/19/88



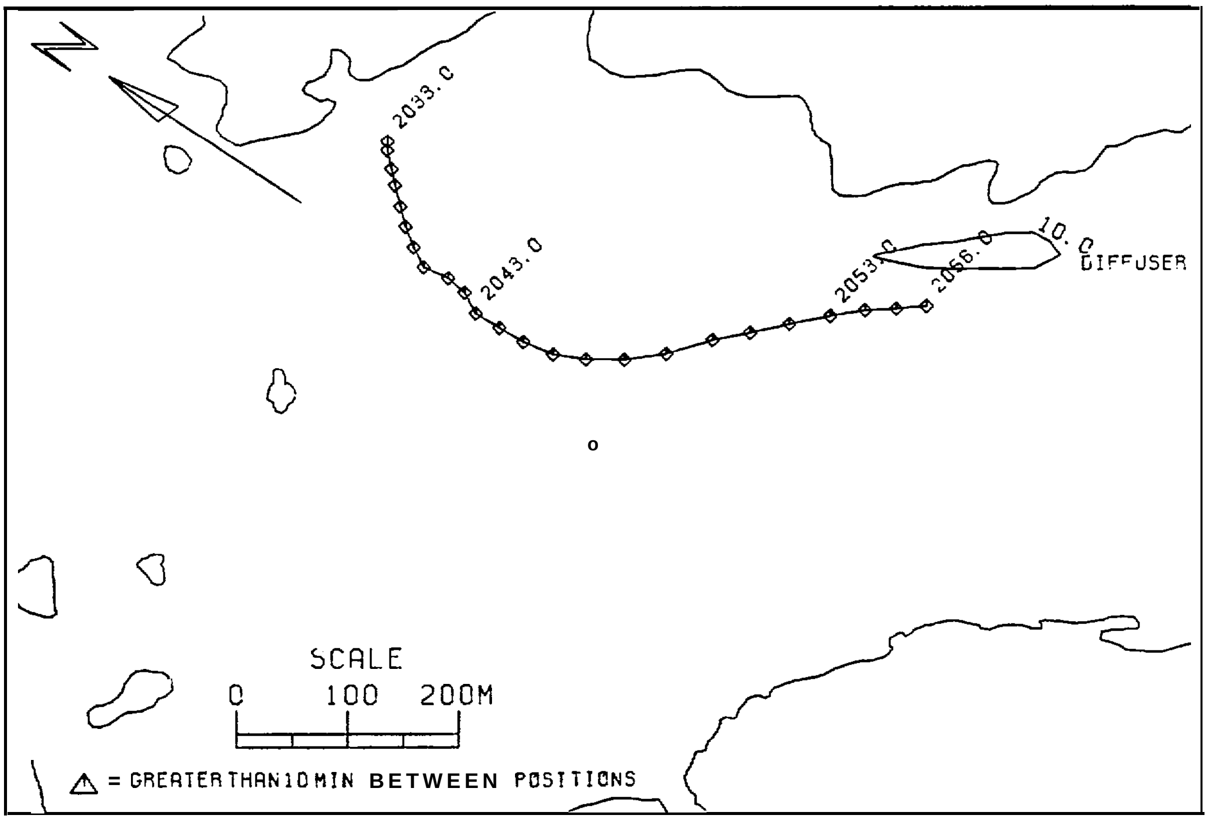
JAKOLOF BAY, FISH 03, CONTROL NO. 1, 7/19/88



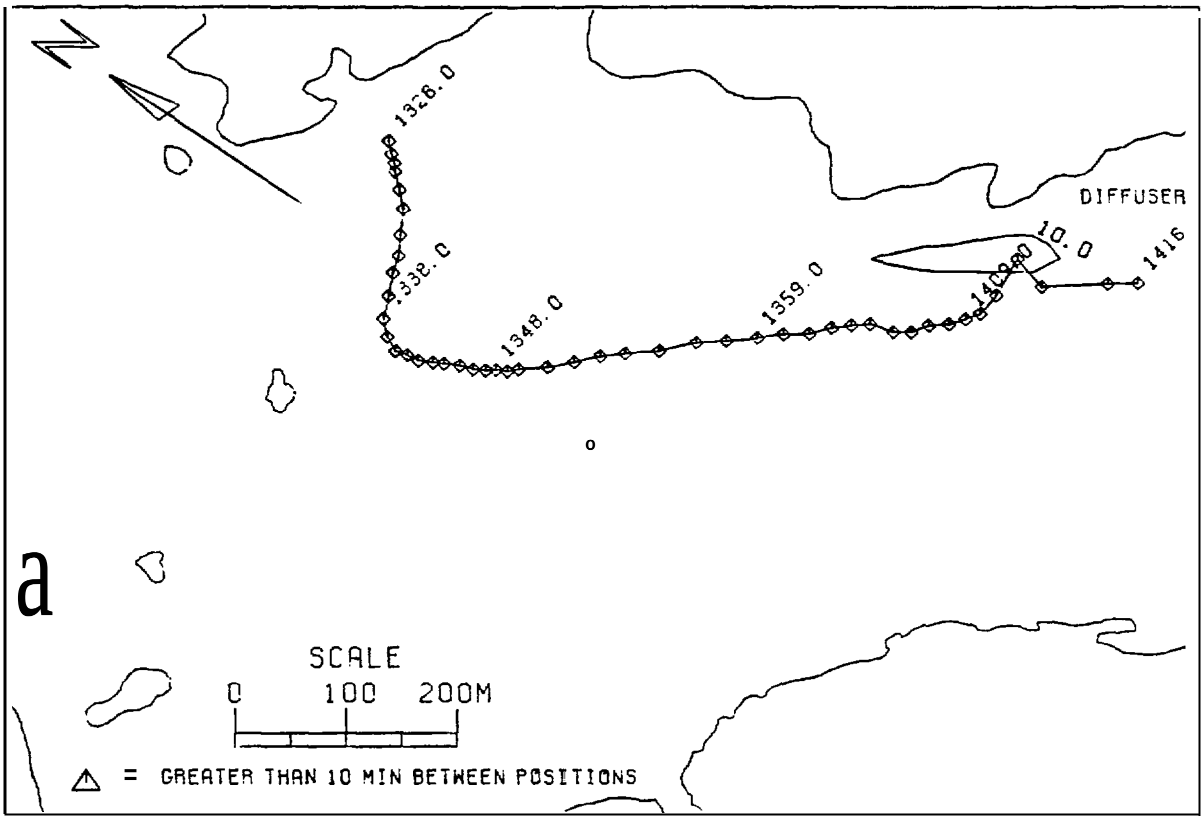
JAKOLOF BAY, FISH 10, CONTROL NO 1, 7/19/88



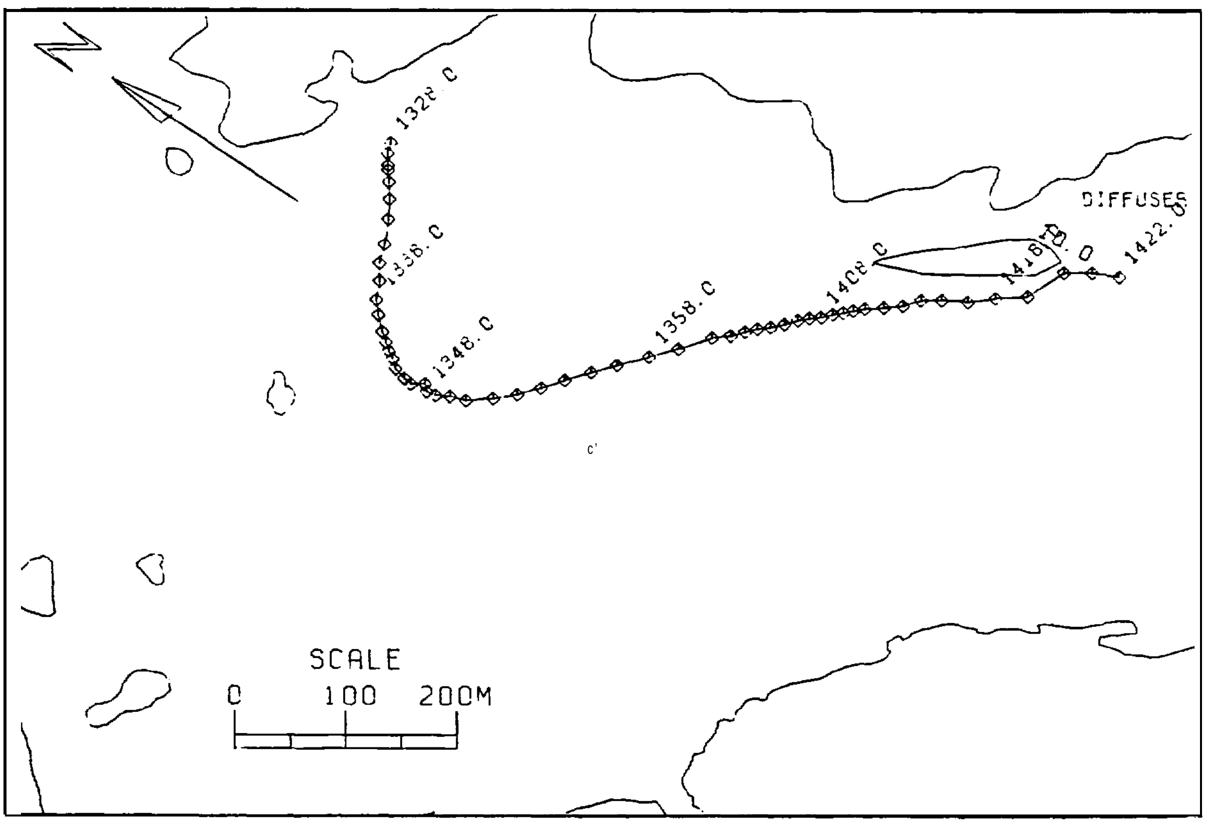
JA KOLOF BAY, FISH 11, CONTROL NO. 1, 7/19/88



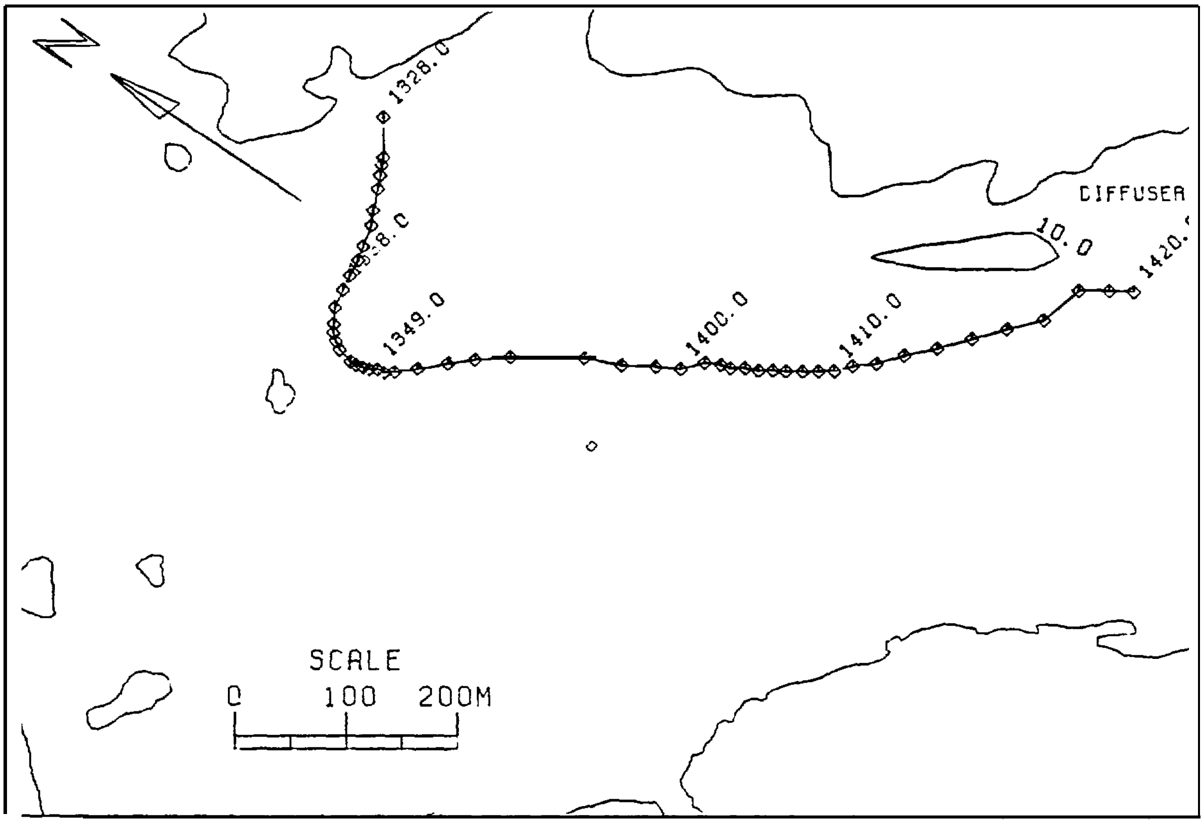
JAKOLOF BAY, FISH 12, CONTROL NO. 1, 7/19/88



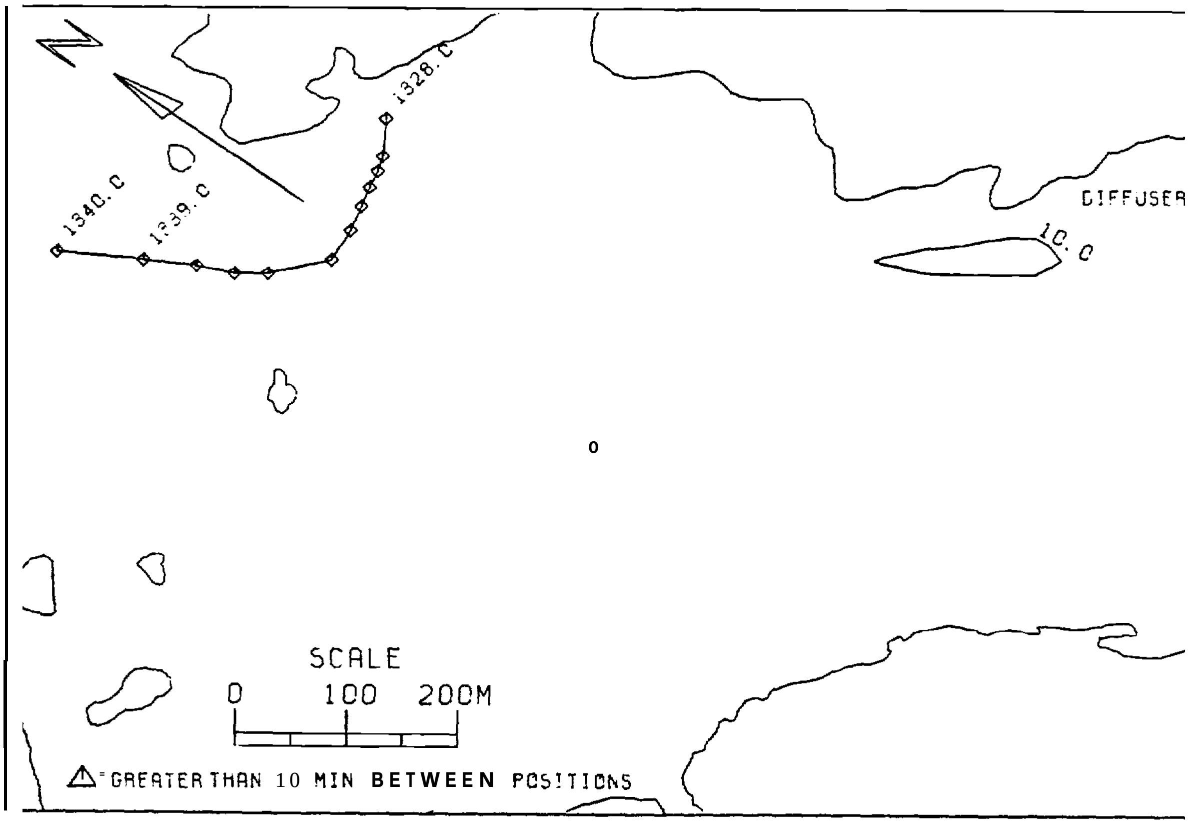
JAKOLOF BAY, FISH 339 CONTROL NO. 2, 7/24/88



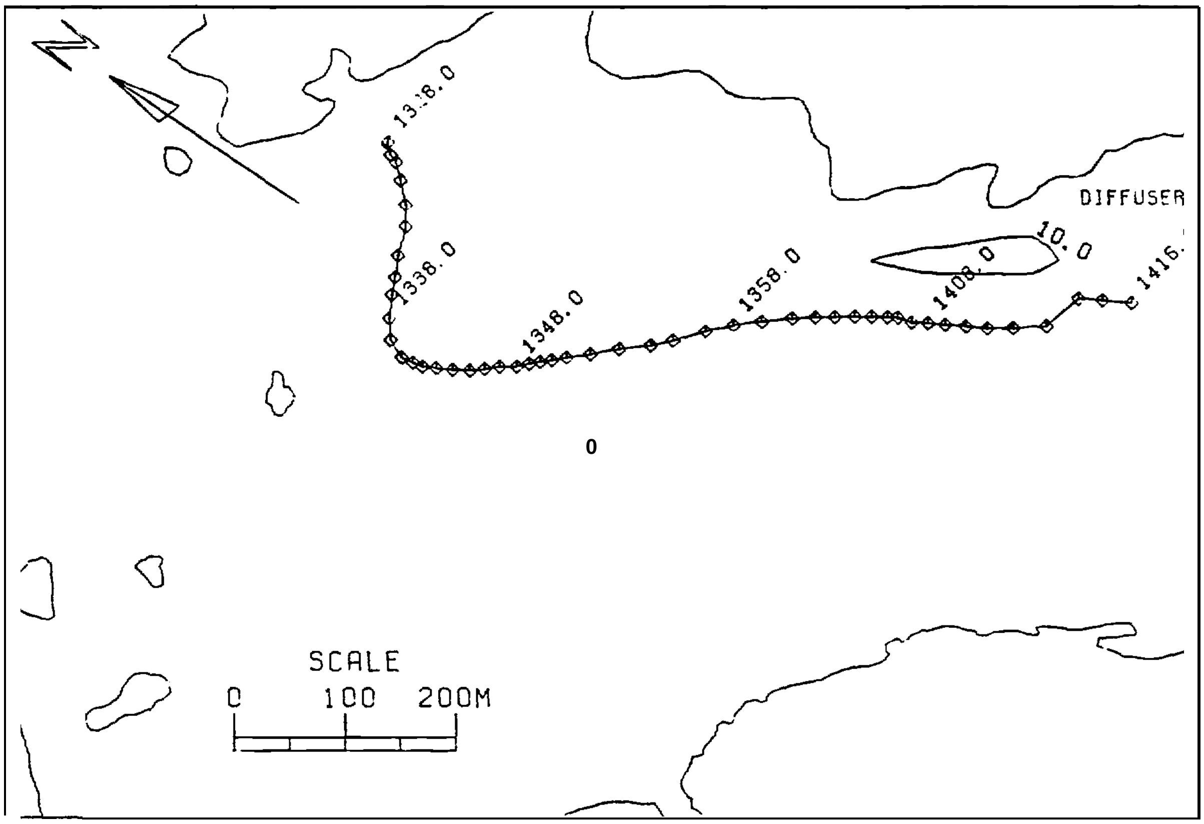
JAKOLOF BAY, FISH 34, CONTROL NO. 2, 7/24/ 88



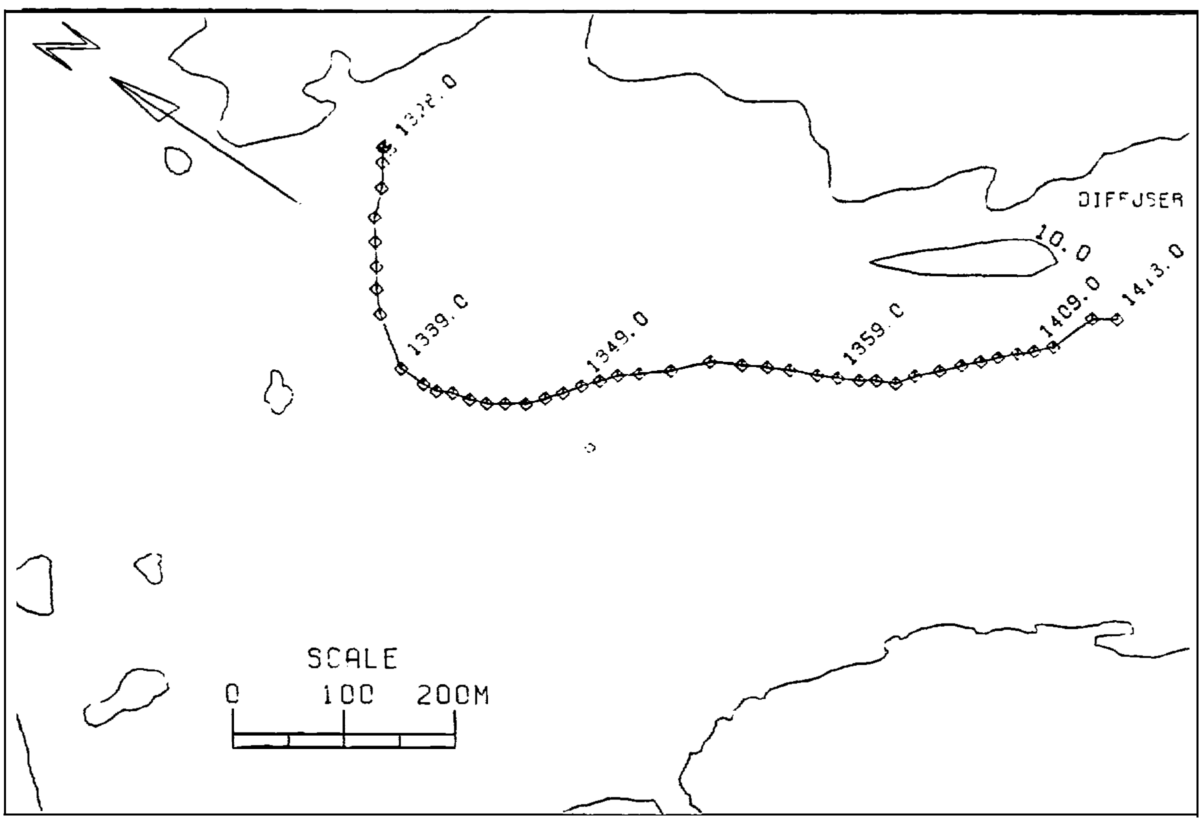
JA KOLOF BAY, FISH 35, CO NT ROL NO. 2, 7/24/88



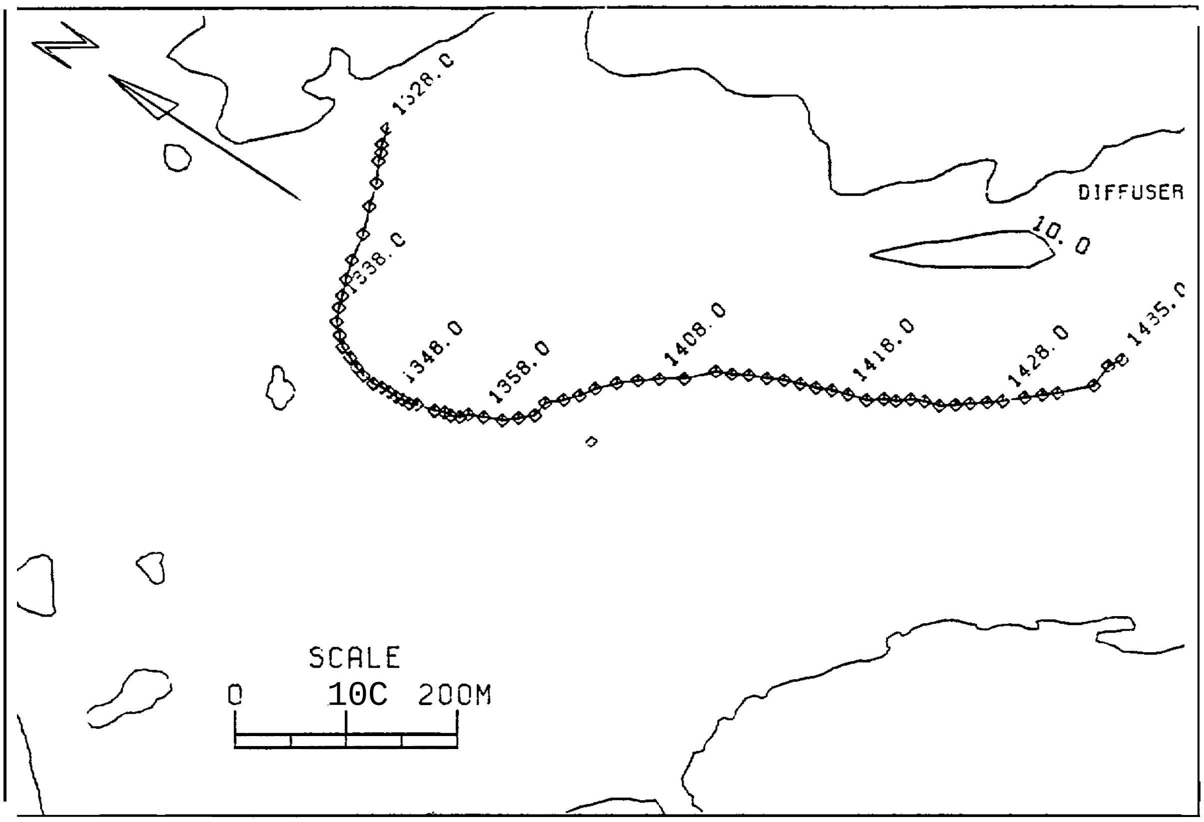
JAKOLOF BAY, FISH 36, CONTROL NO. 2, 7/24/88



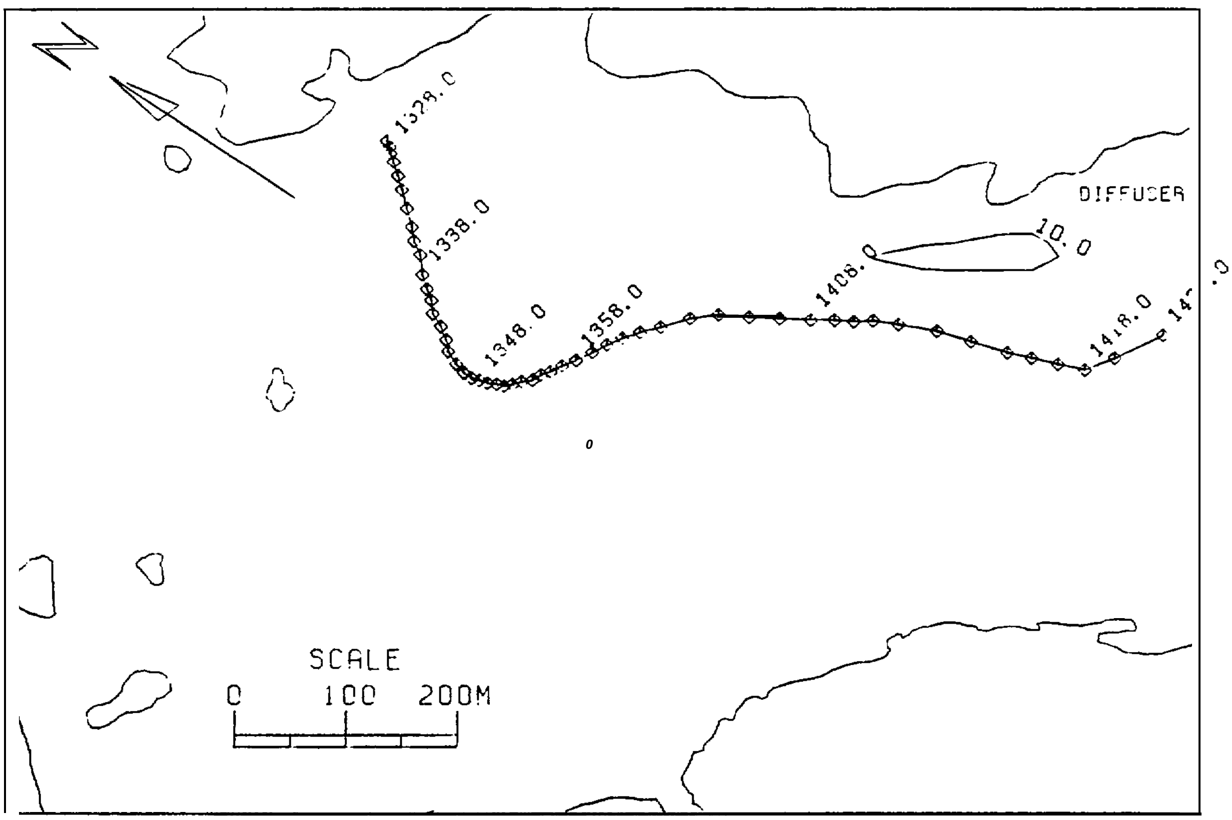
JAKOLOF BAY, FISH 37, CONTROL NO. 2, 7/24/88



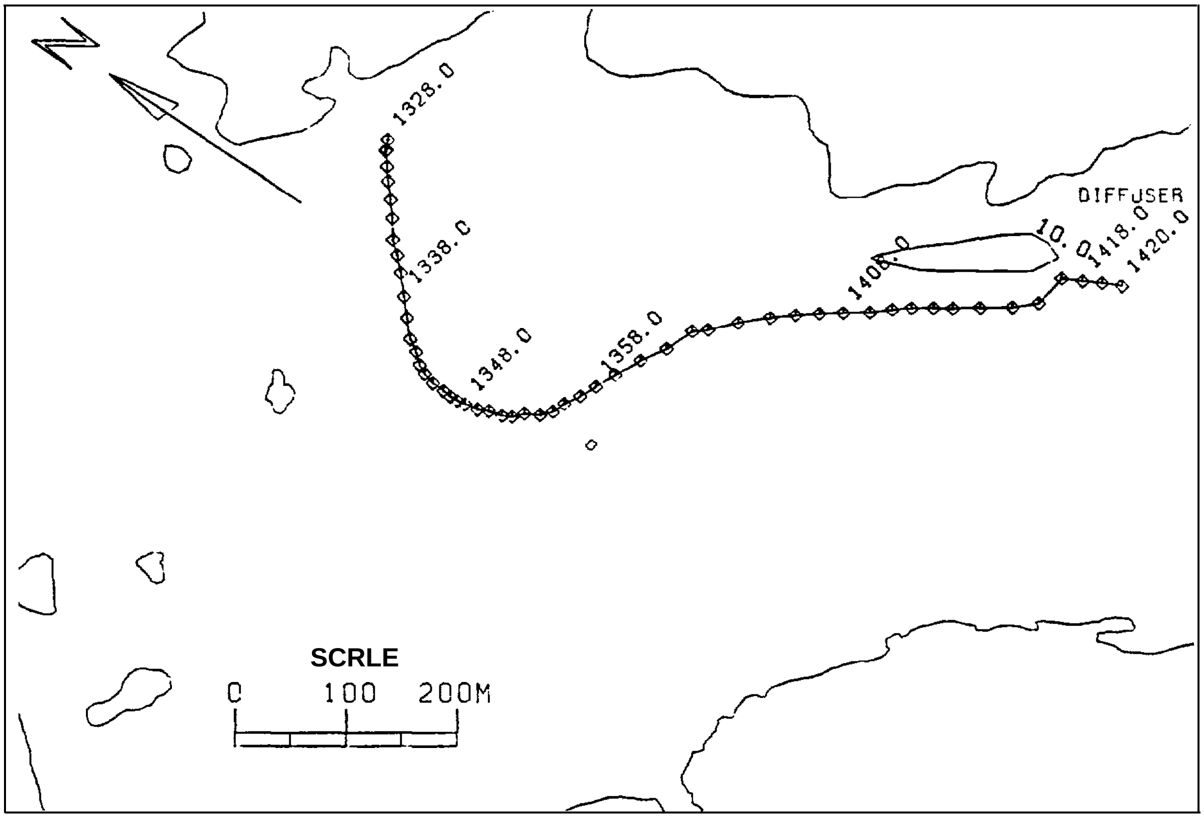
JA KOLOF BAY, FISH 38, CONTROL NO. 2, 7/24/88



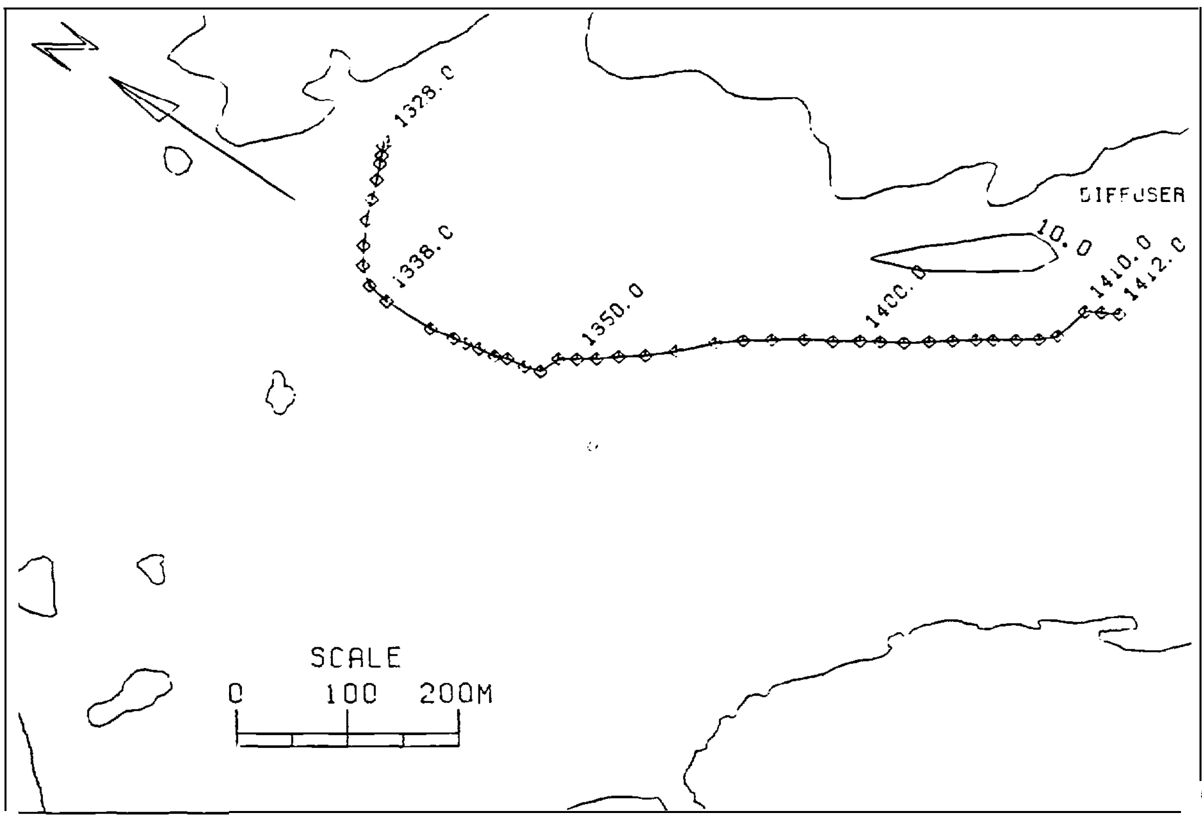
JAKOLOF BAY, FISH 39, CONTROL NO. 2, 7/24/88



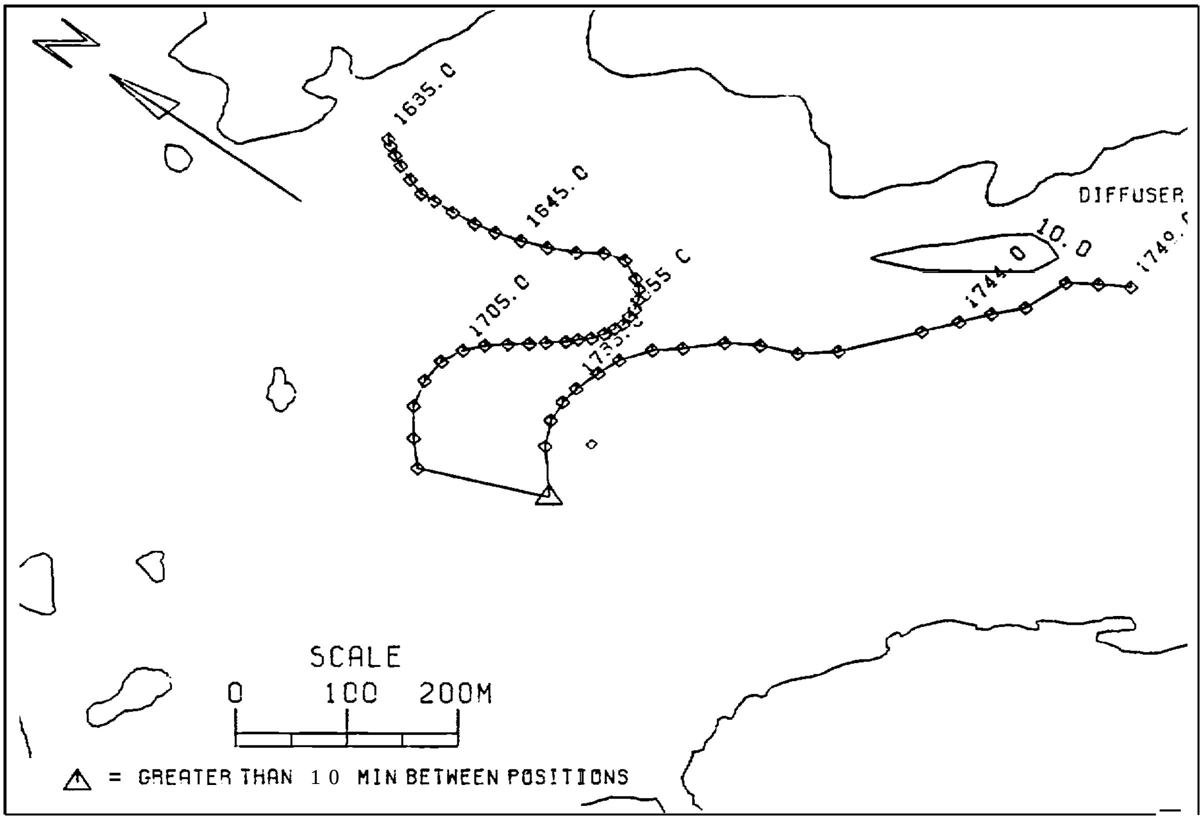
JAKOLOF BAY, FISH 40, CONTROL NO. 2, 7/24/88



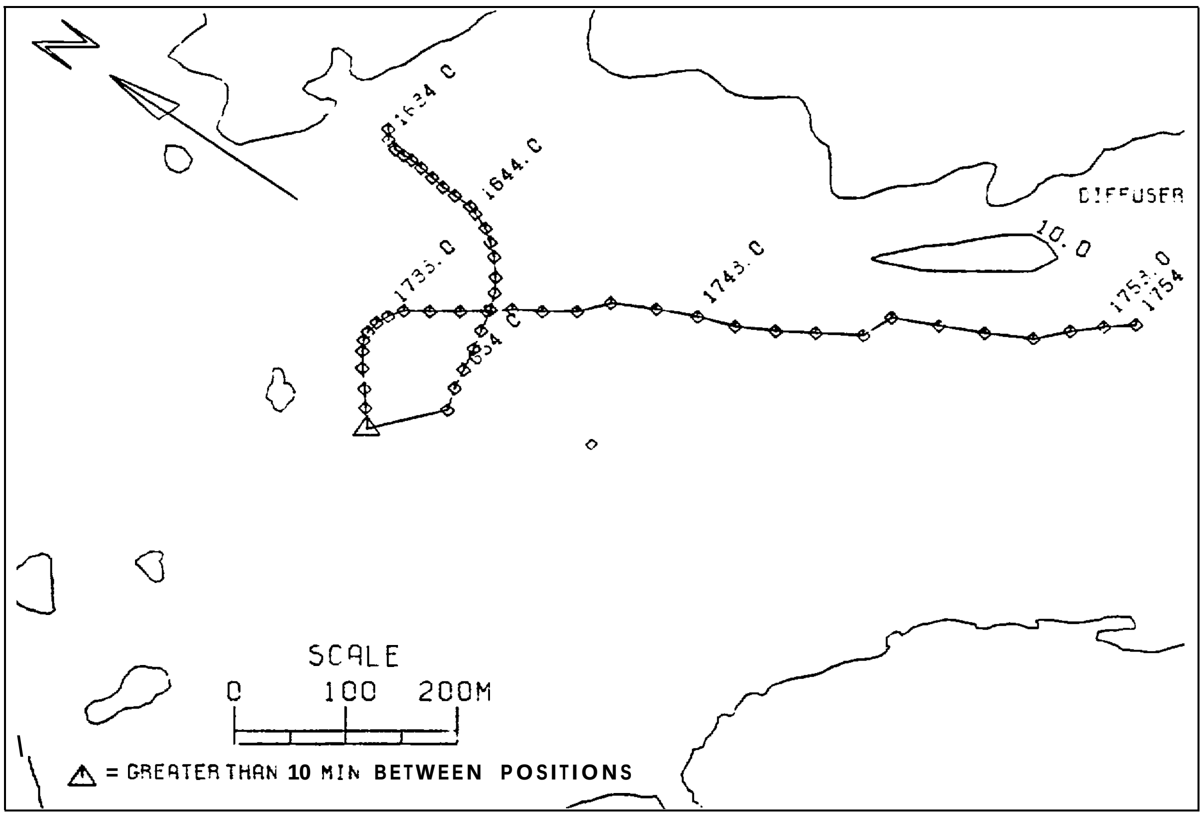
JAKOLOF BAY, FISH 41, CONTROL NO. 2, 7/24/88



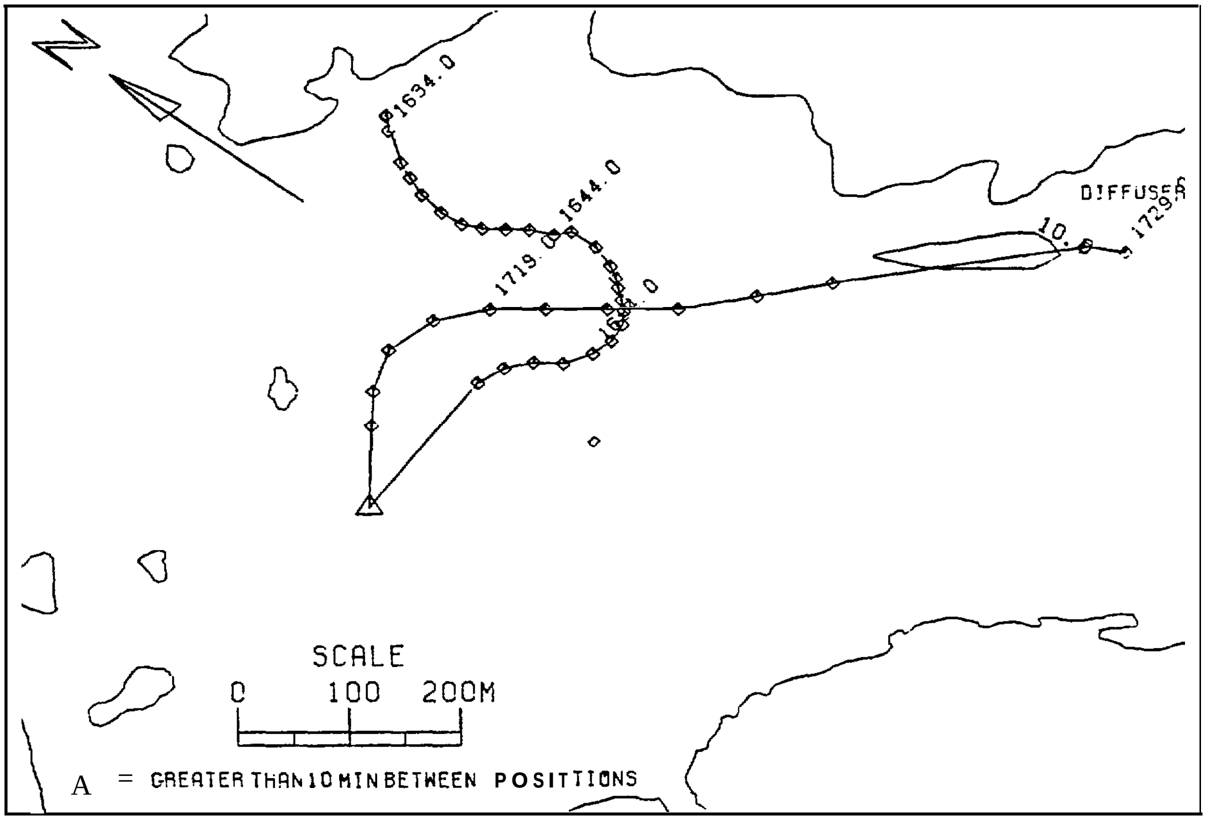
JAKOLOF BAY, FISH 42, CONTROL NO.2, 7/24/88



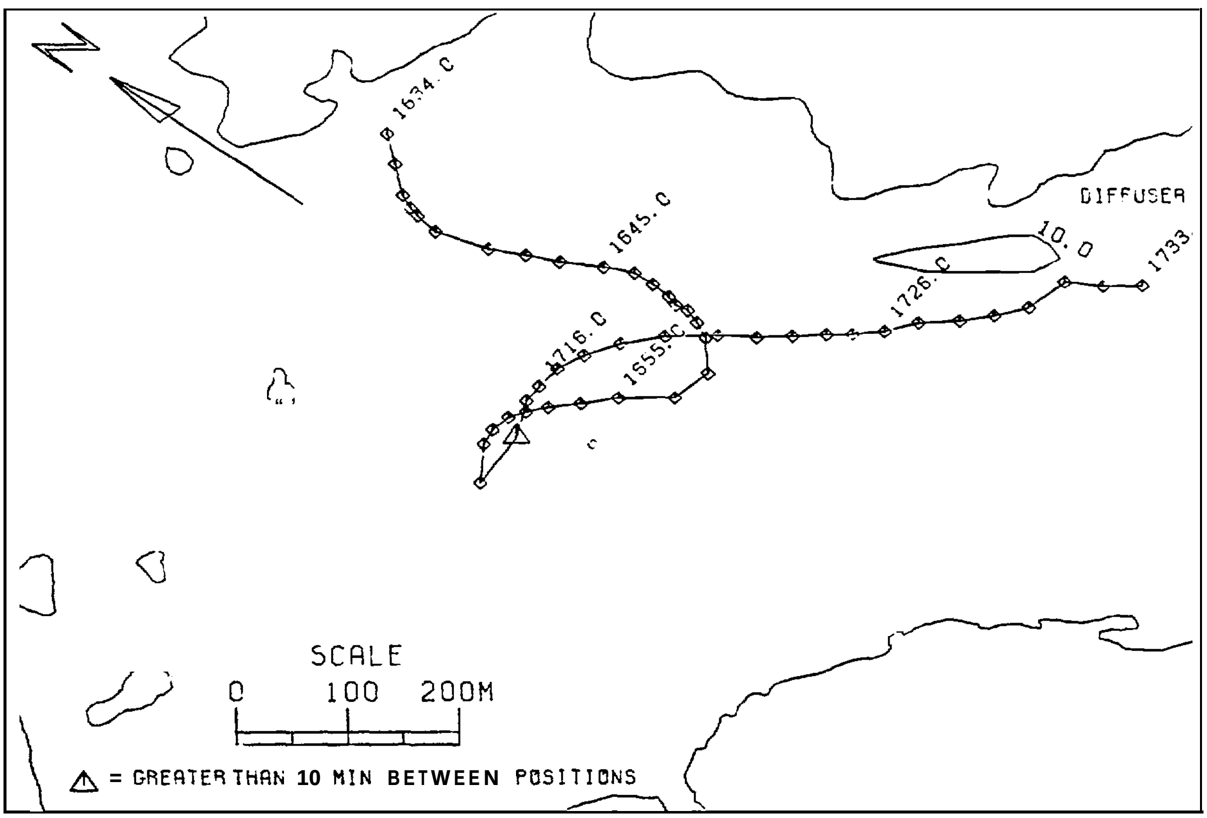
JAKOLOF BAY, FISH 53, CONTROL NO. 3, 7/'28/88



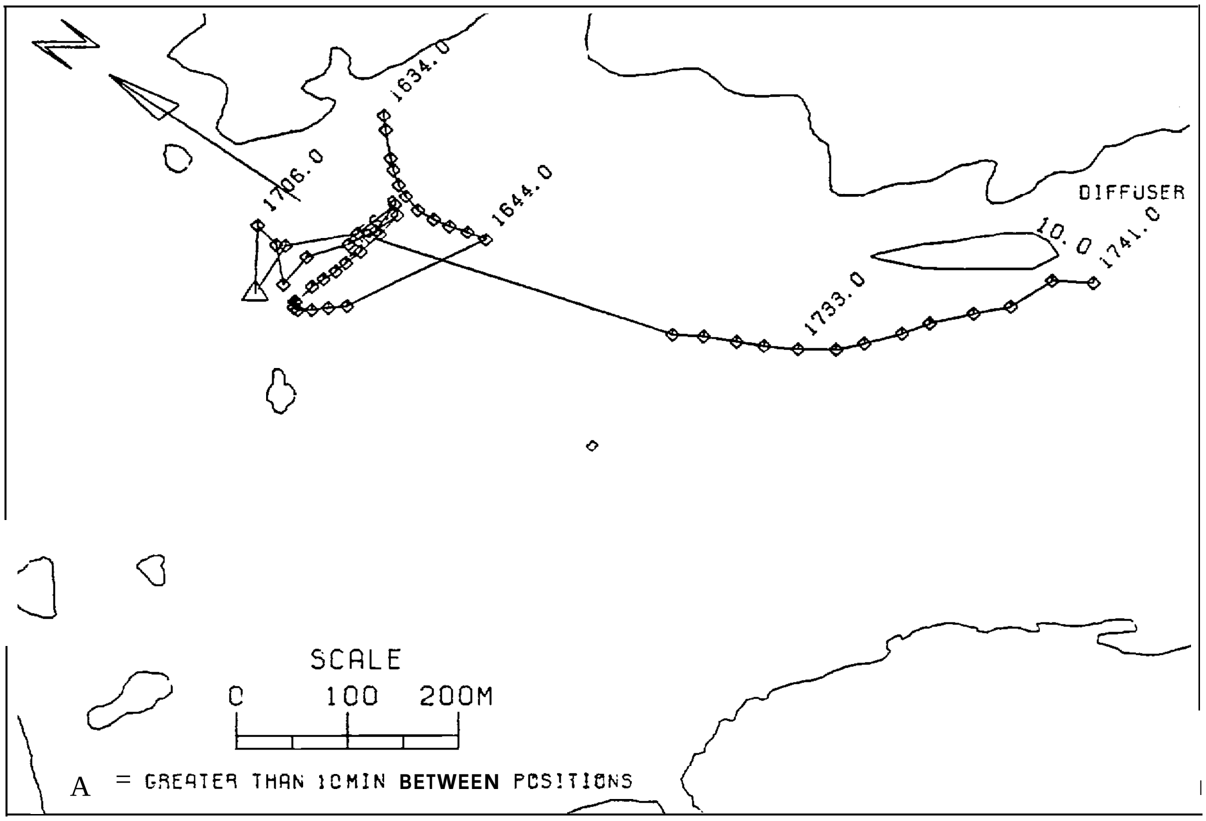
JAKOLOF BAY, FISH 54, CONTROL NO. 3, 7/28/88



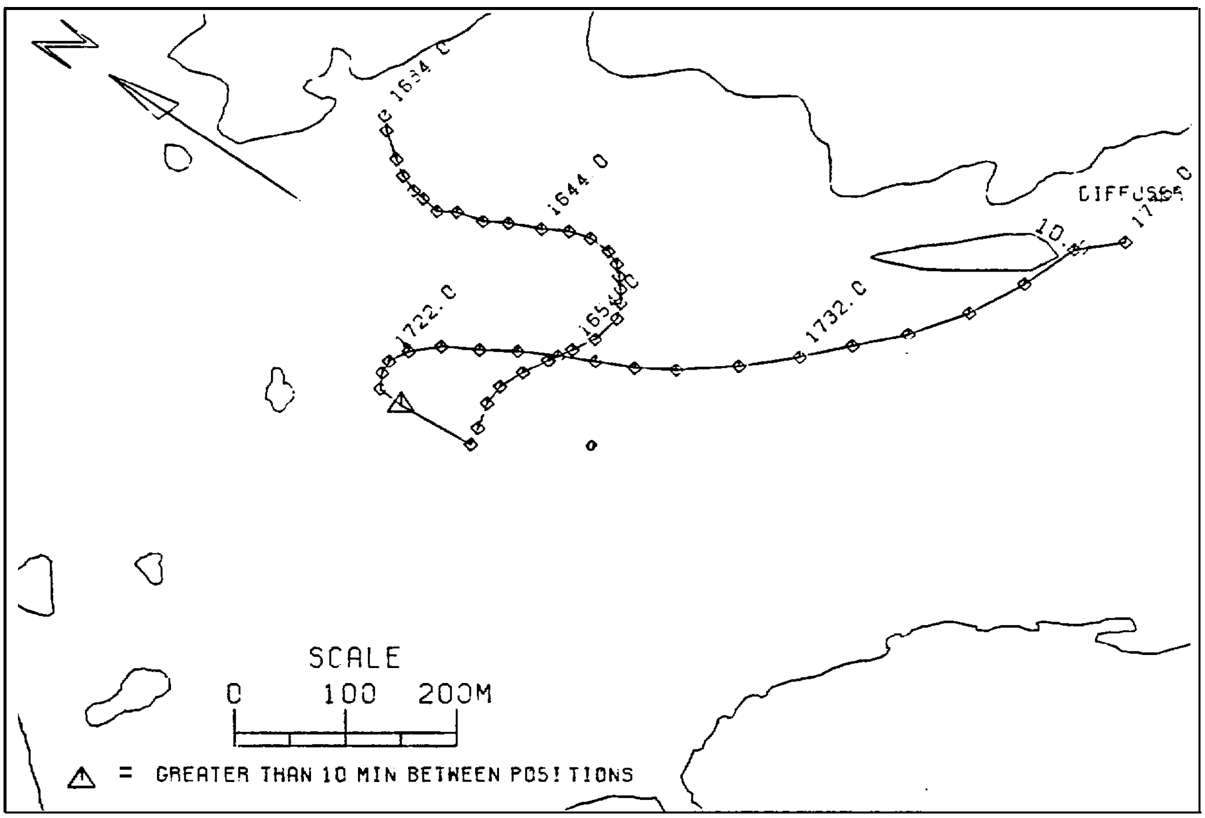
JAKOLOF BAY, FISH 55, CONTROL NO. 3, 7/28/88



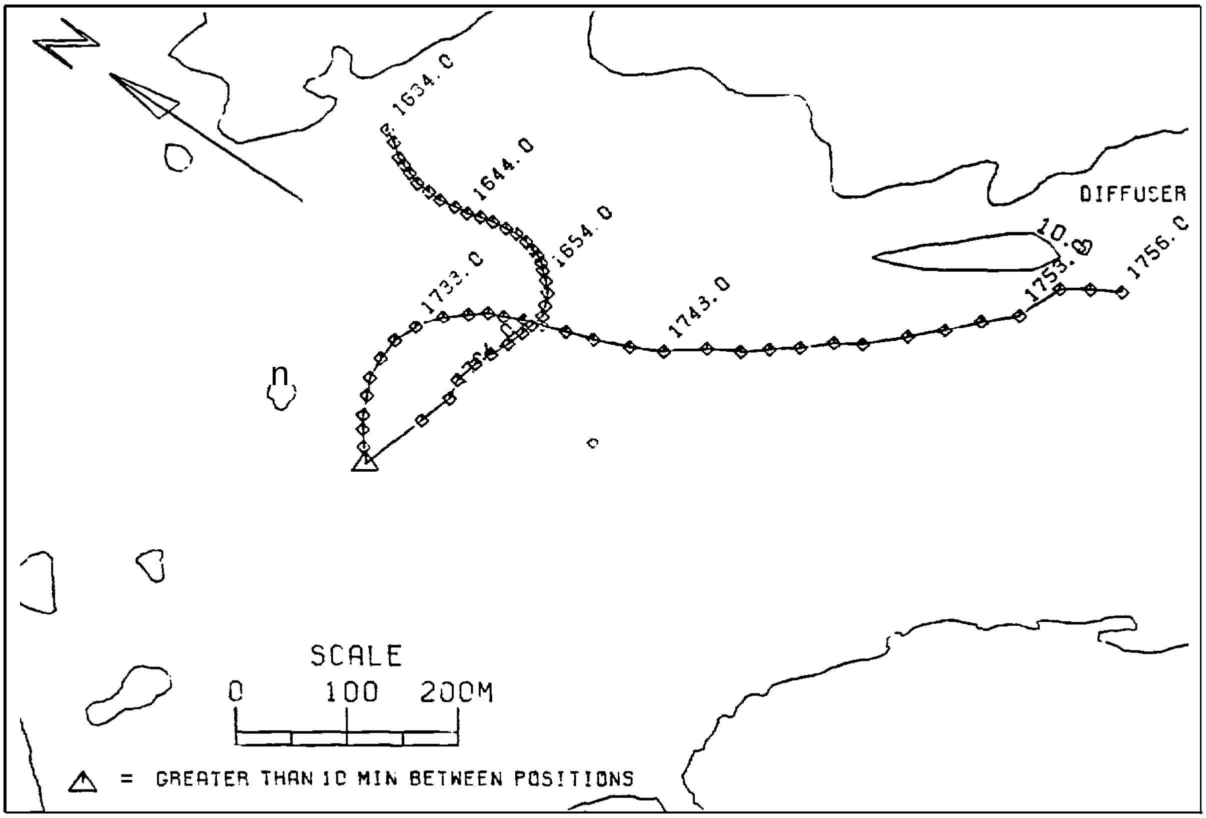
JAKOLOF BAY, FISH 56, CONTROL NO. 3, 7/28/88



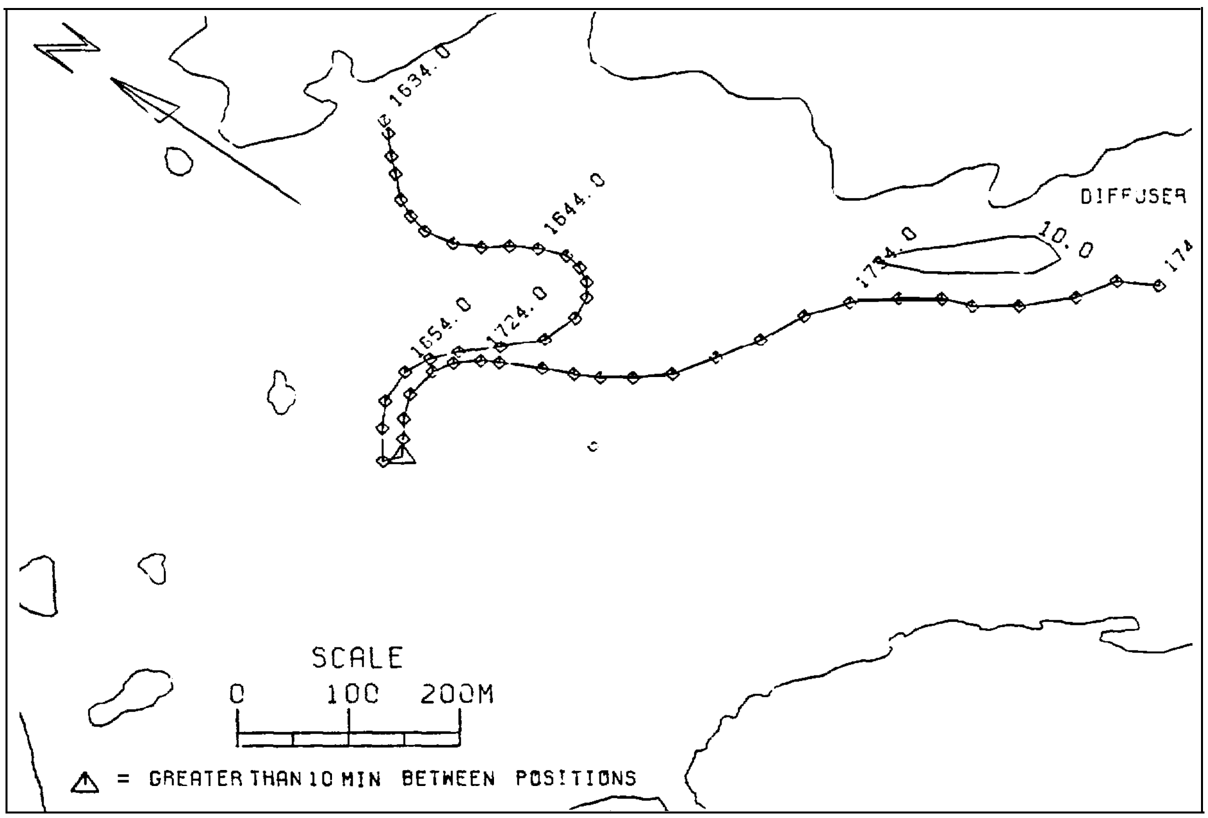
JAKOLOF BAY, FISH 57, CONTROL NO. 3, 7/28/88



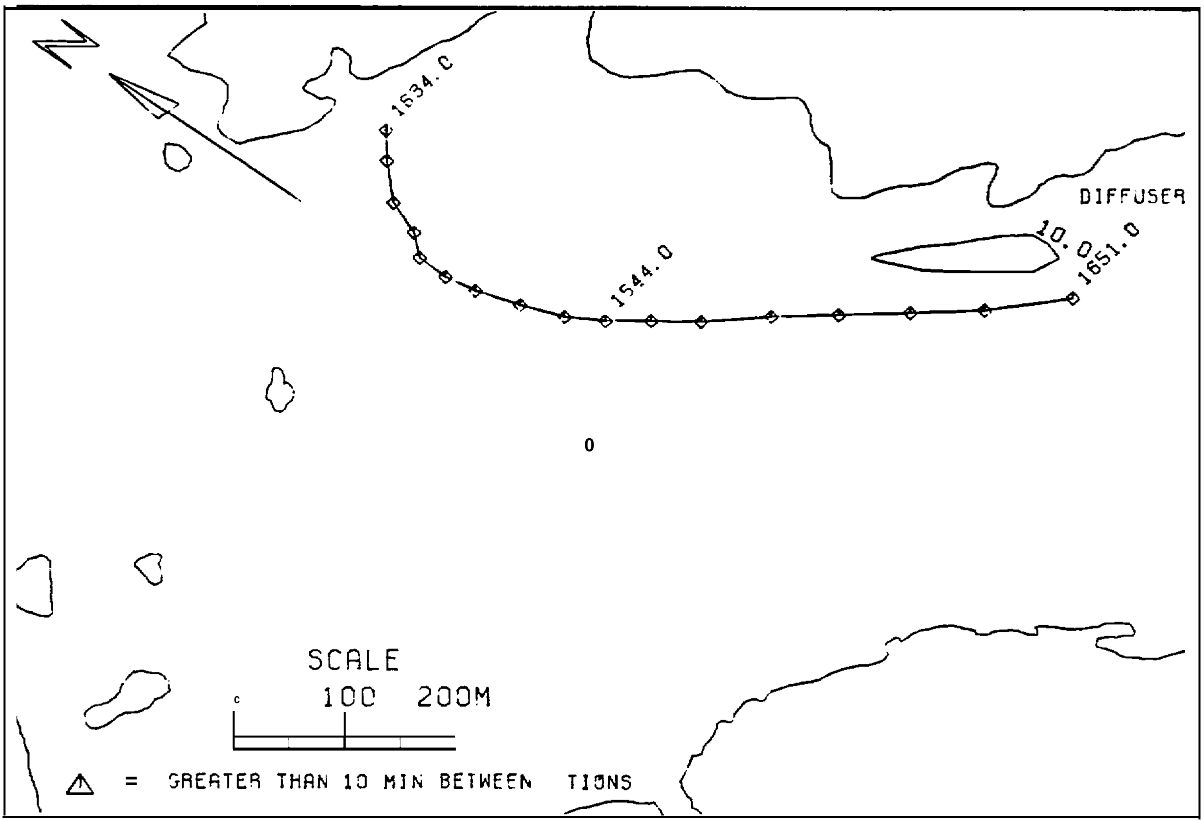
JAKOLOF BAY, FISH 58, CONTROL NO. 3, 7/28/88



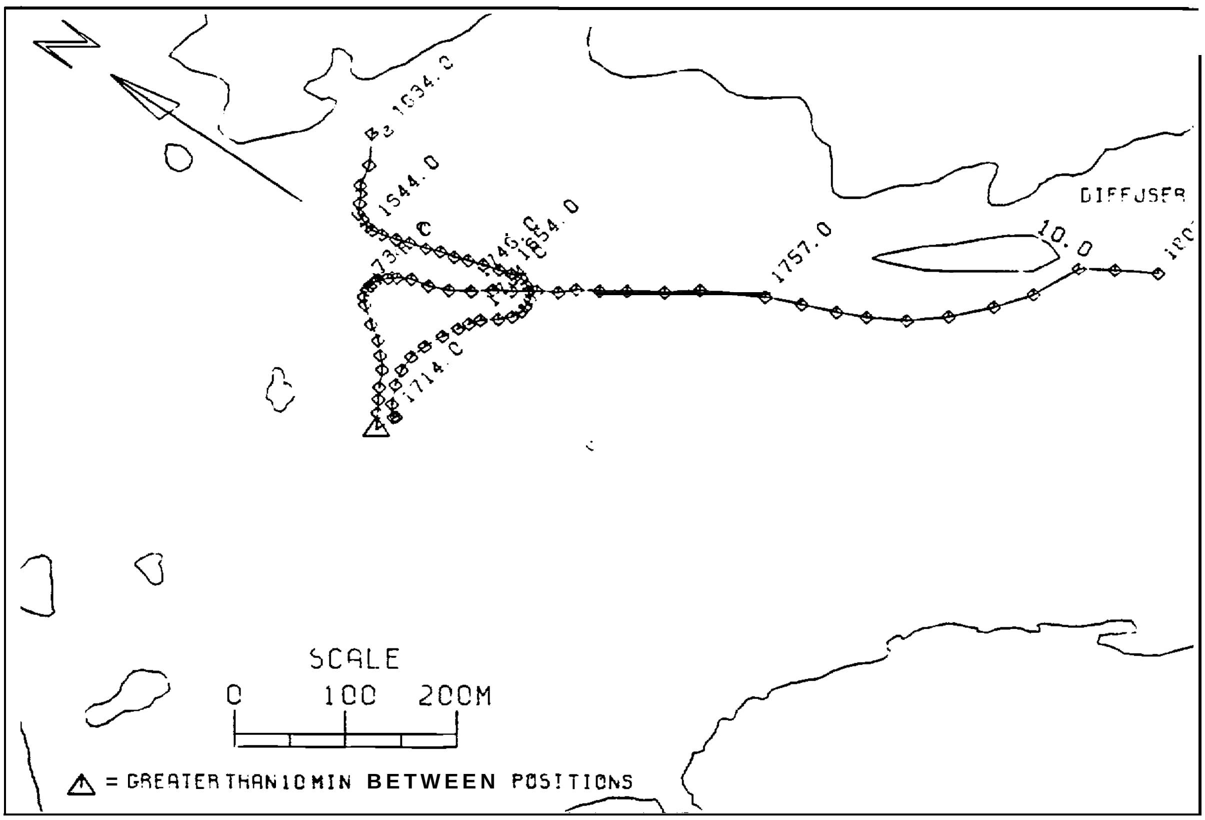
JAKOLOF BAY, FISH 59, CONTROL NO. 3, 7/28/88



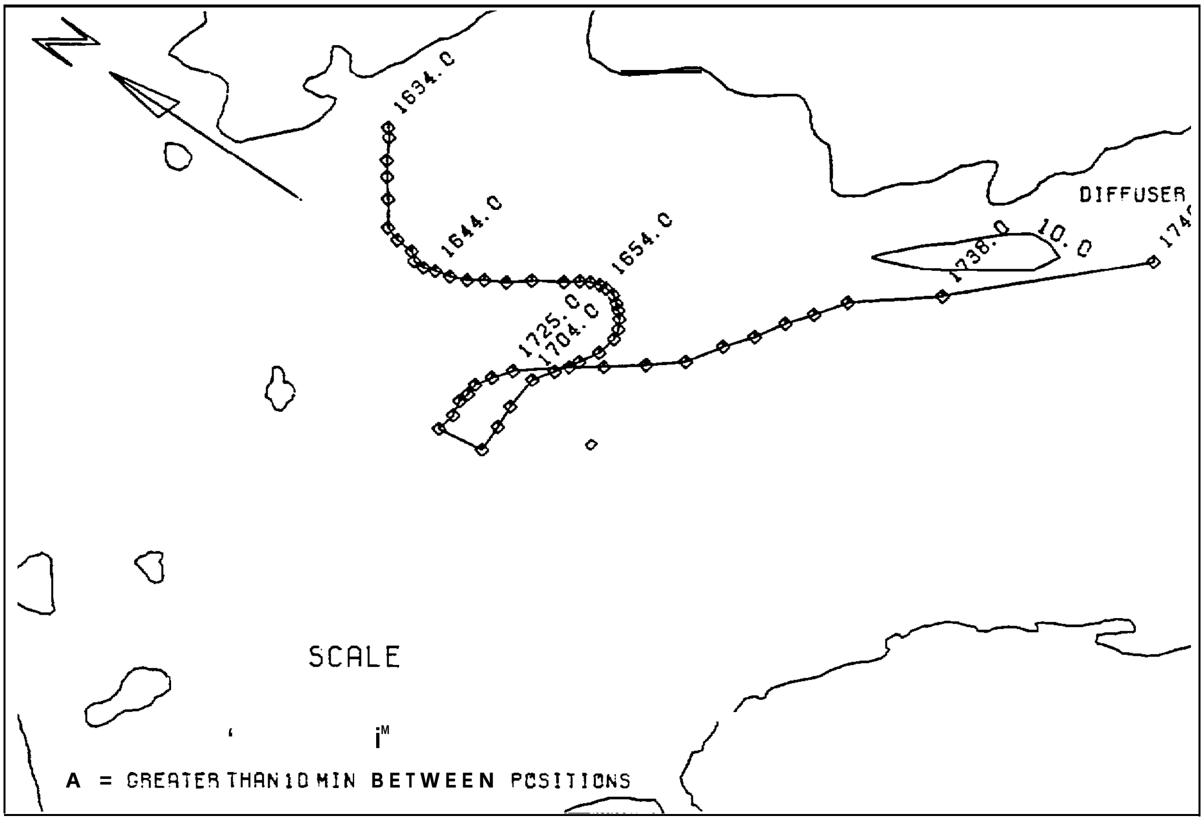
JAKOLOF BAY, FISH 60, CONTROL NO. 3, 7/28/88



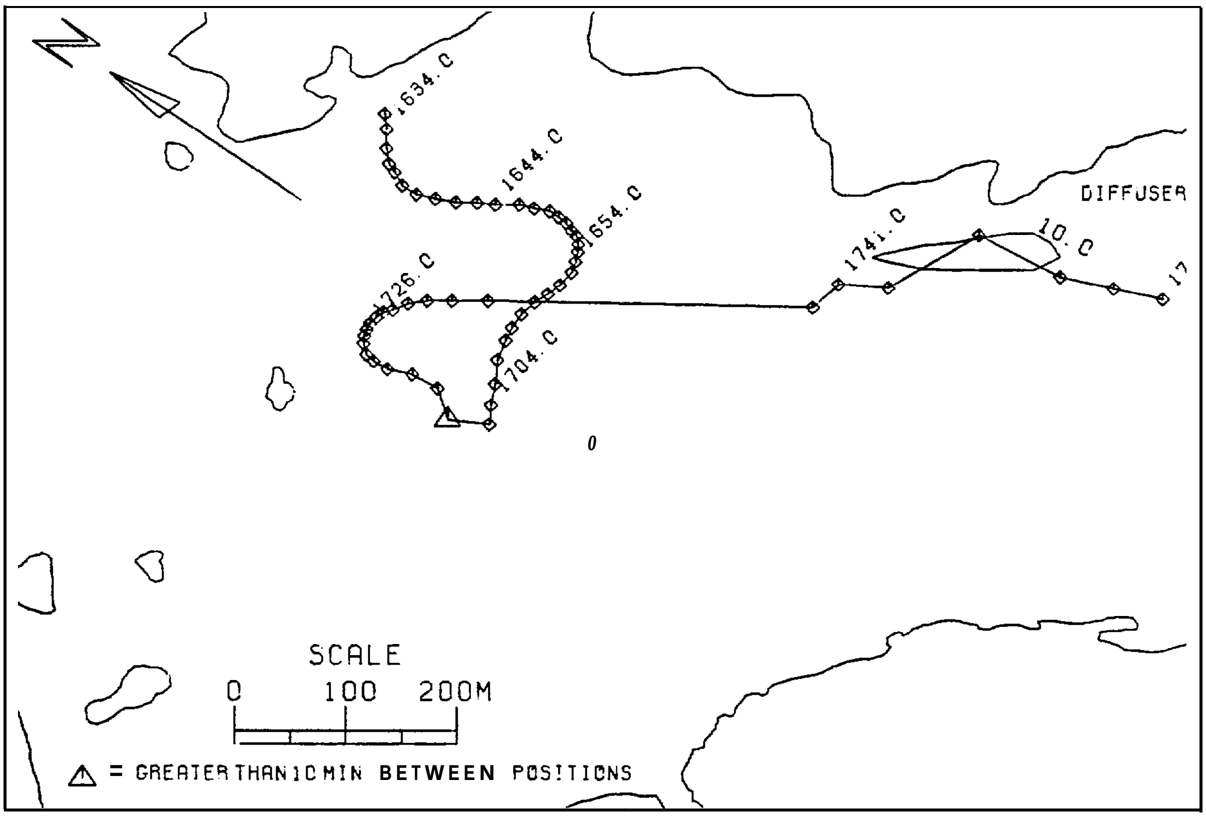
JAKOLOF BAY, FISH 61, CONTROL NO. 3, 7/28/88



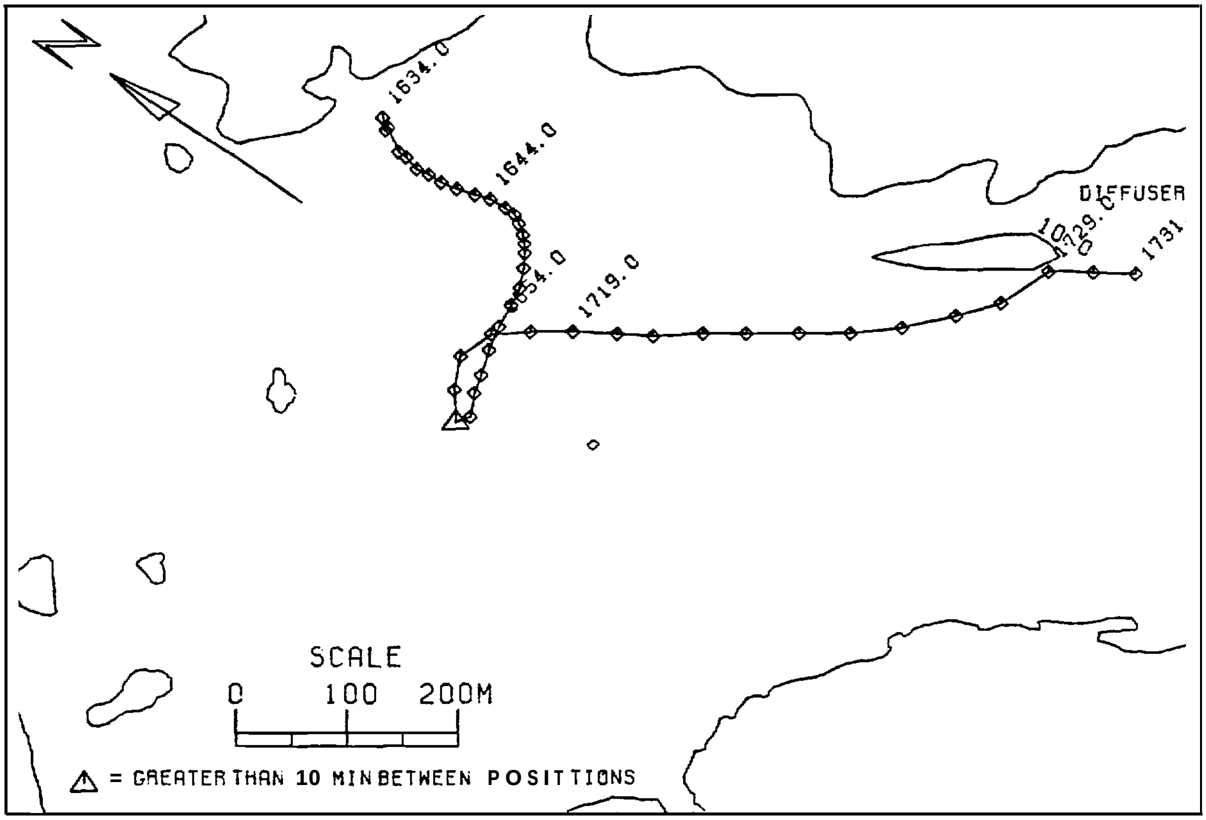
JAKOLOF BAY, FISH 62, CONTROL NO. 3, 7/28/88



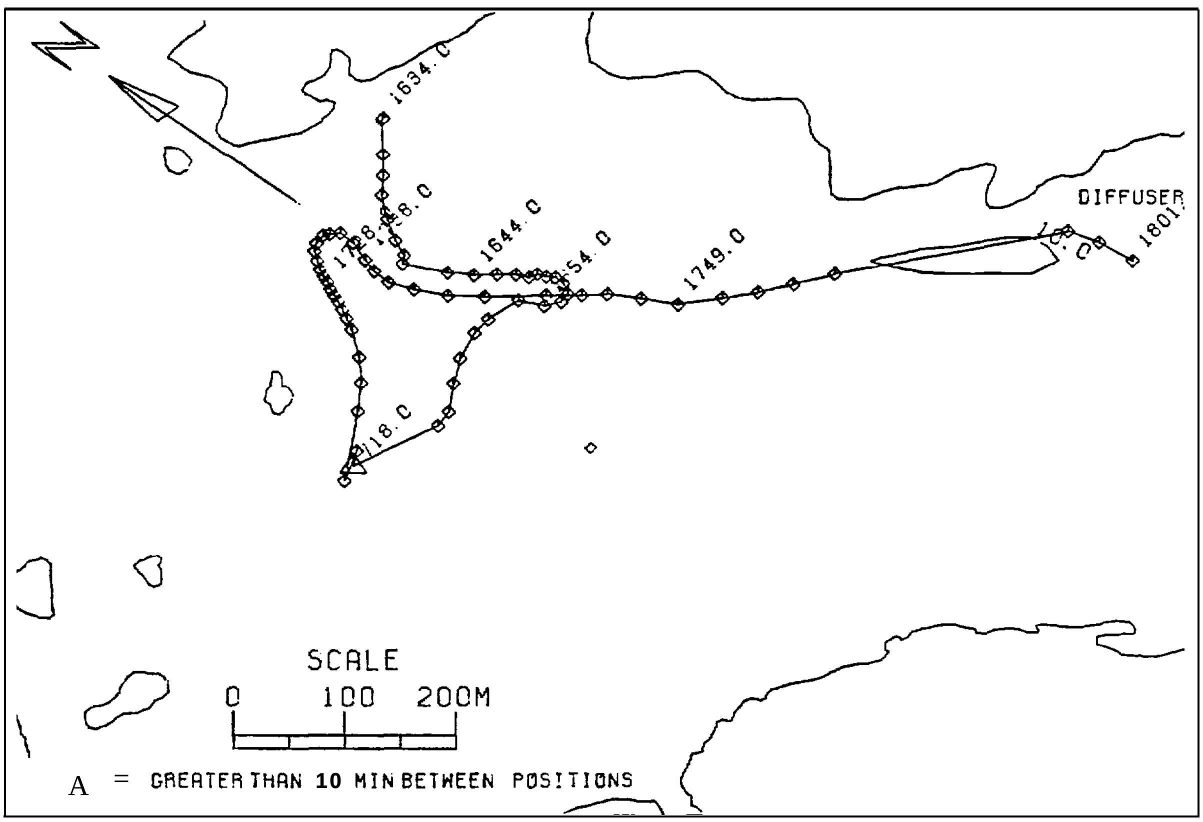
JA KOLOF BAY, FISH 63, CONTROL NO. 3, 7/28/88



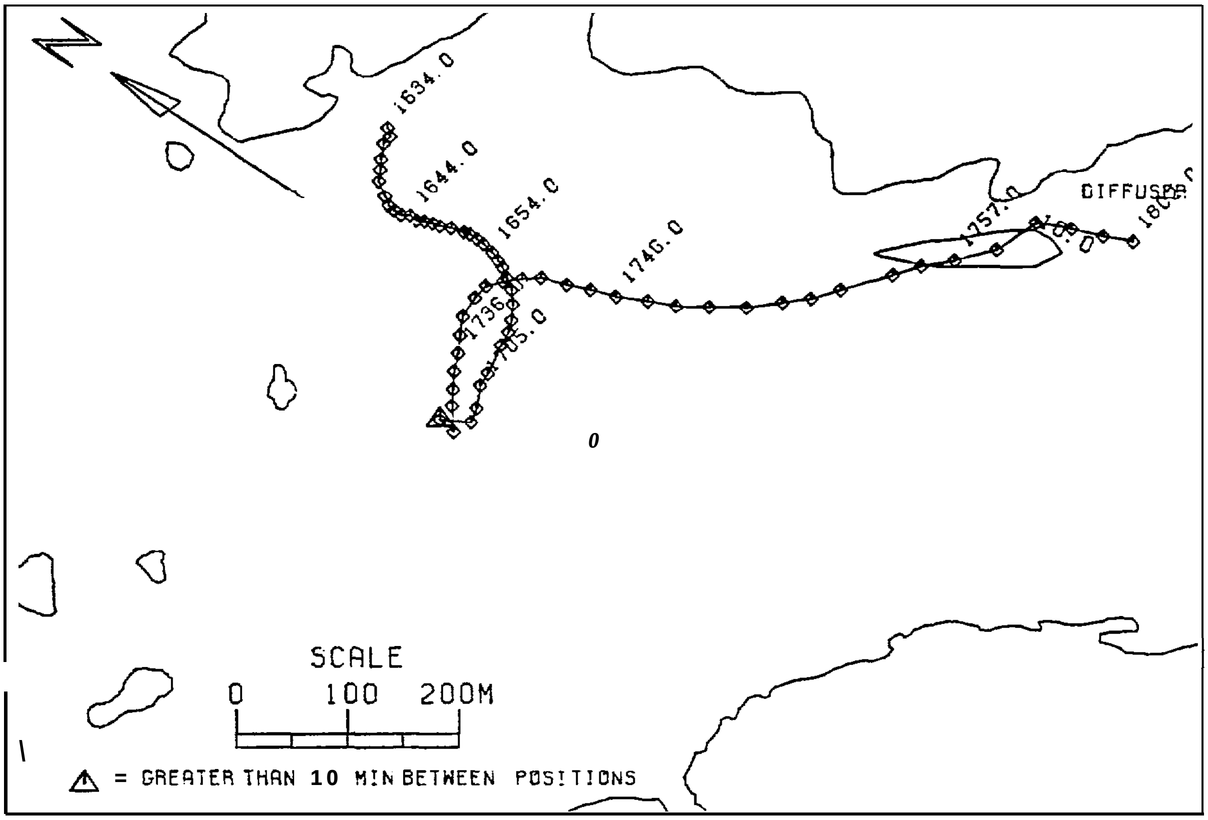
JAKOLOF BAY, FISH 64, CONTROL NO. 3, 7/28/88



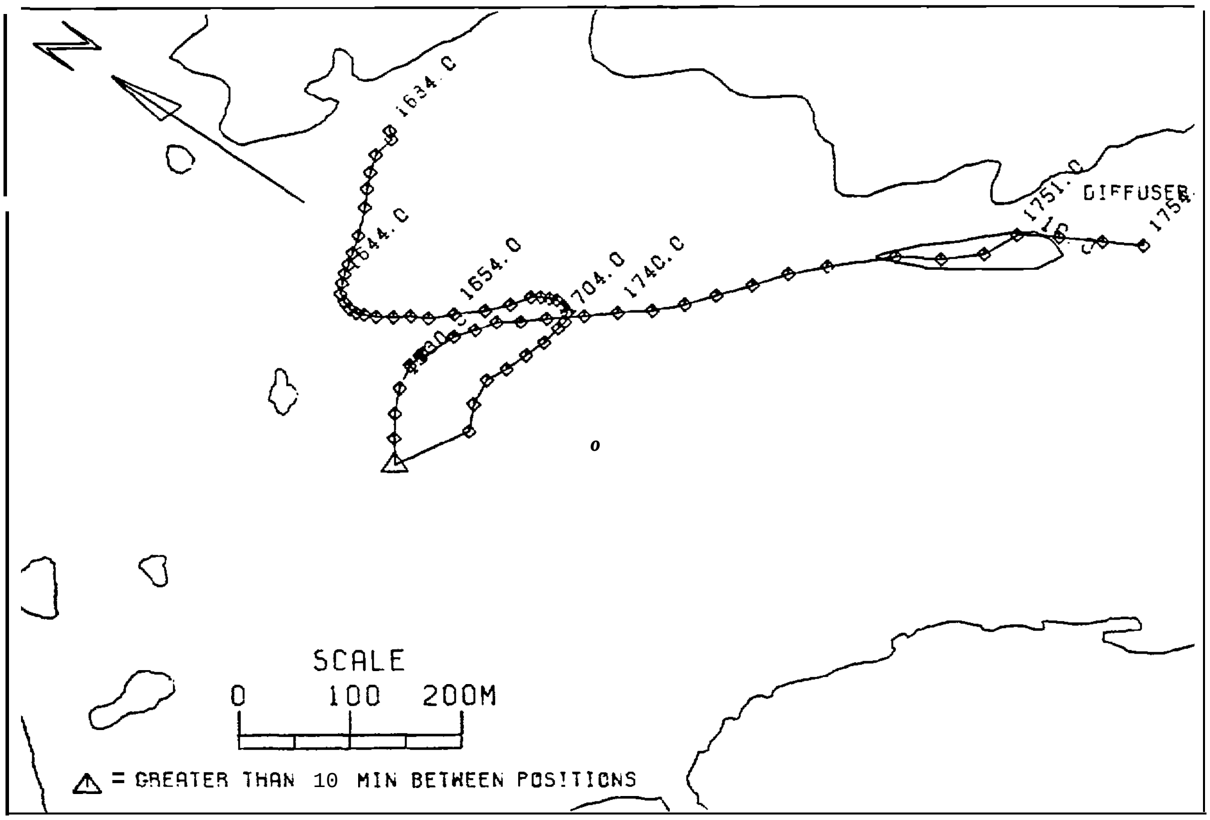
JAKOLOF BAY, FISH 67, CONTROL NO. 3, 7/28/88



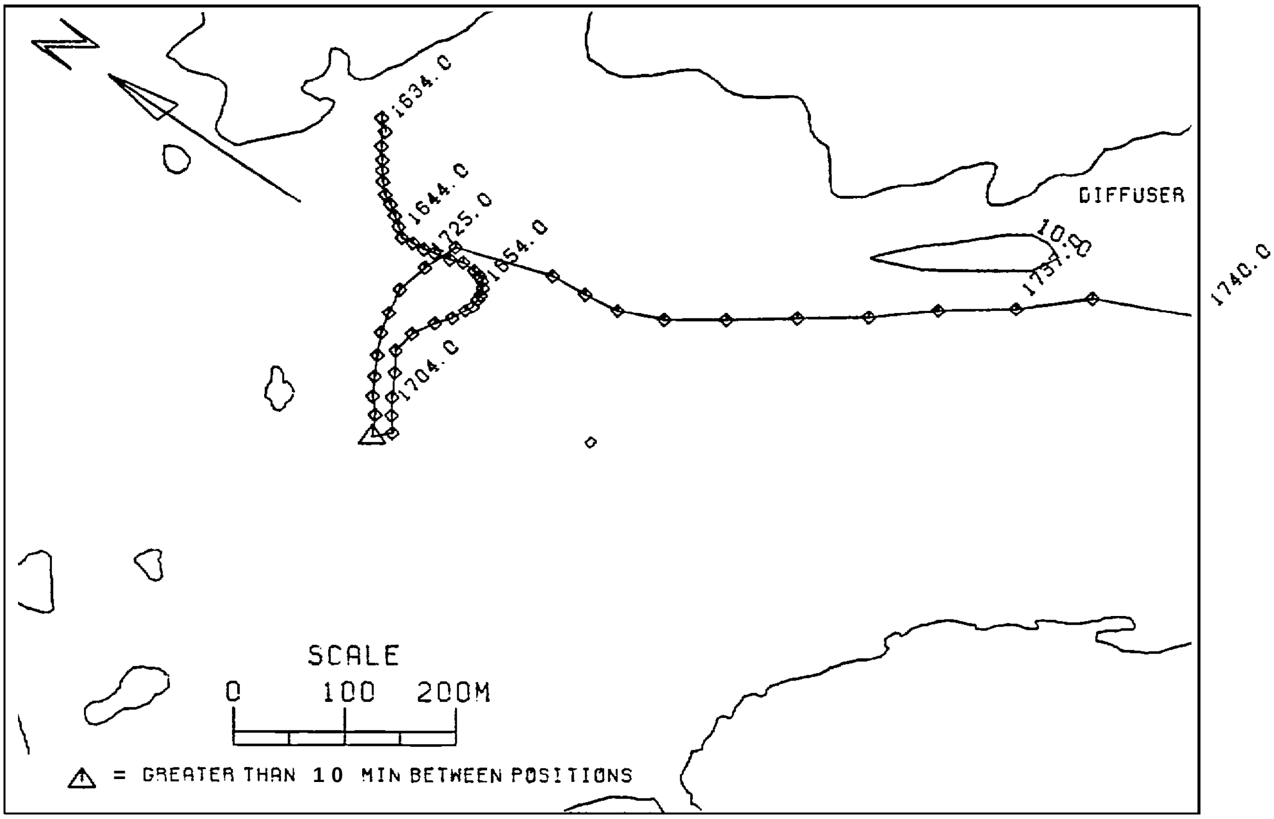
JAKOLOF BAY, FISH 68, CONTROL NO. 3, 7/28/88



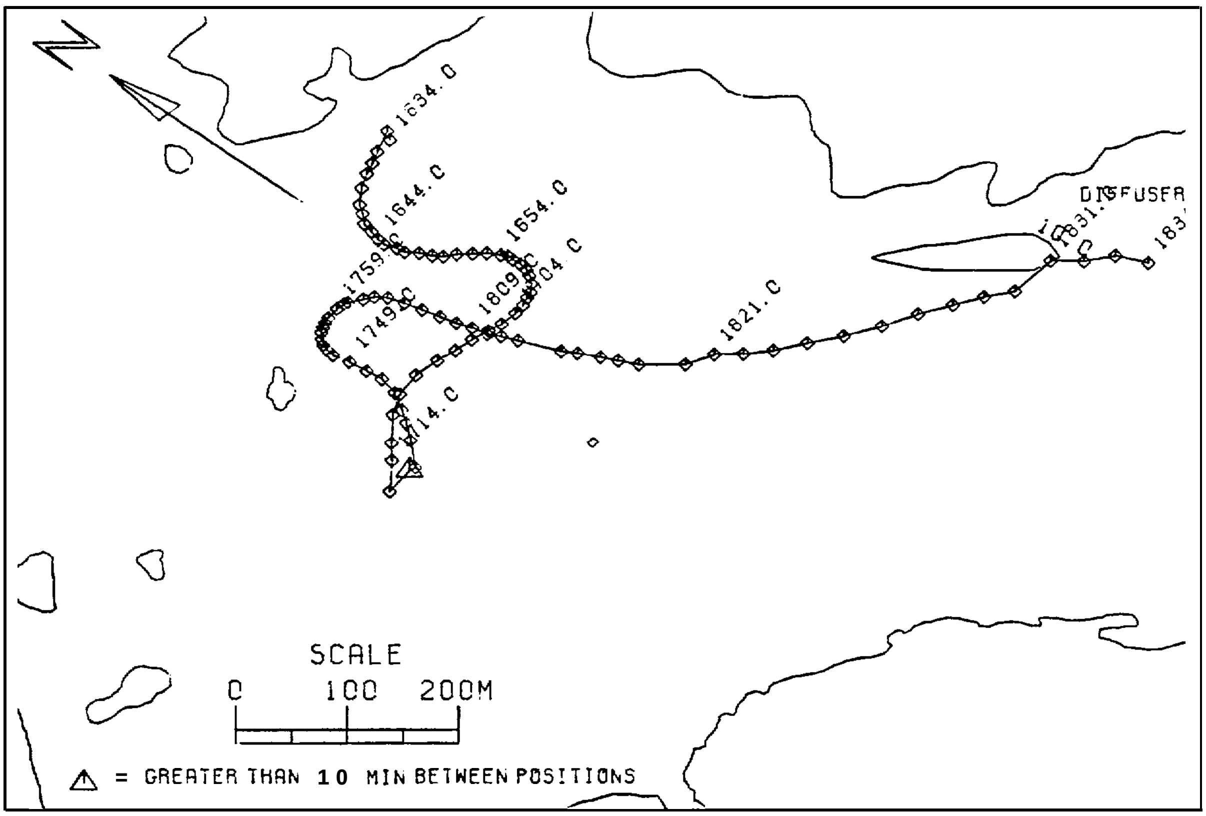
JAKOLOF BAY, FISH 69, CONTROL NO. 3, 7/28/88



JAKOLOF BAY. FISH 70, CONTROL NO. 3, 7/28/88



JAKOLOF BAY, FISH 719 CONTROL NO. 3, 7/28/'88

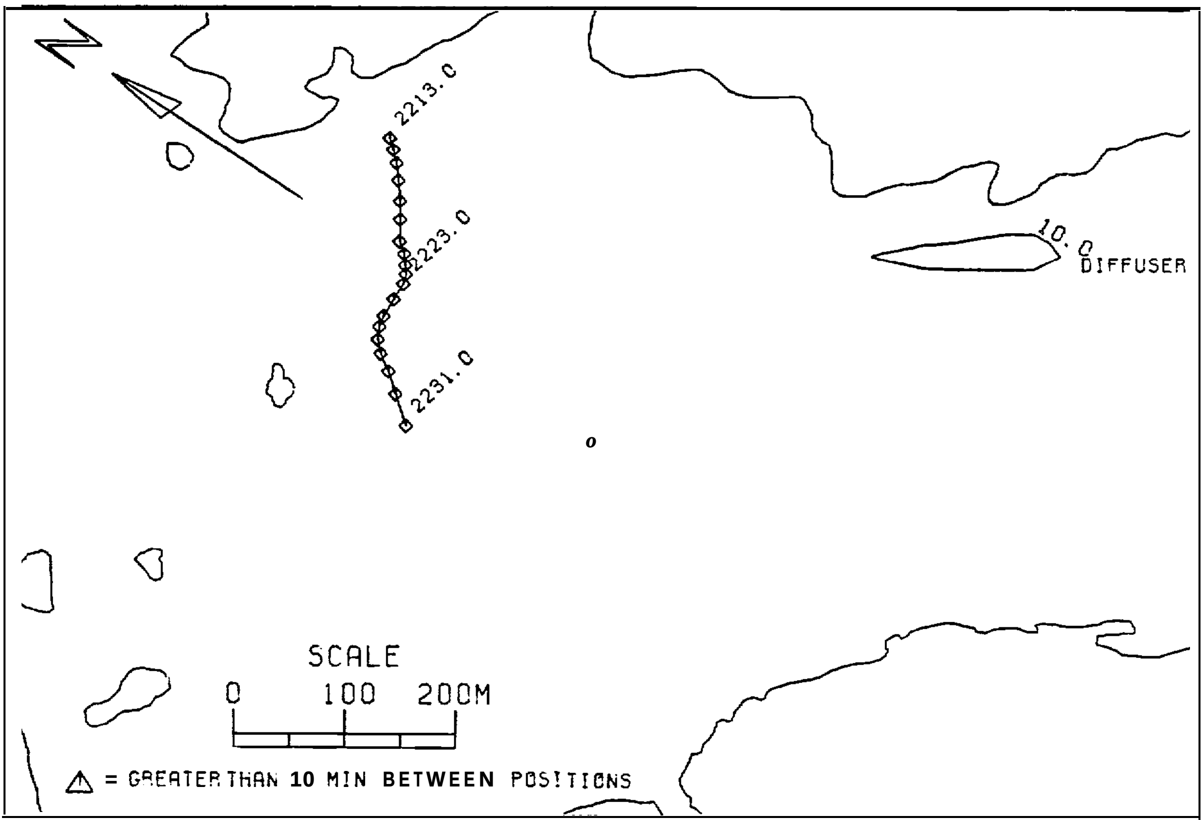


JAKOLOF BAY, FISH 72, CONTROL NO. 3, 7/28/88

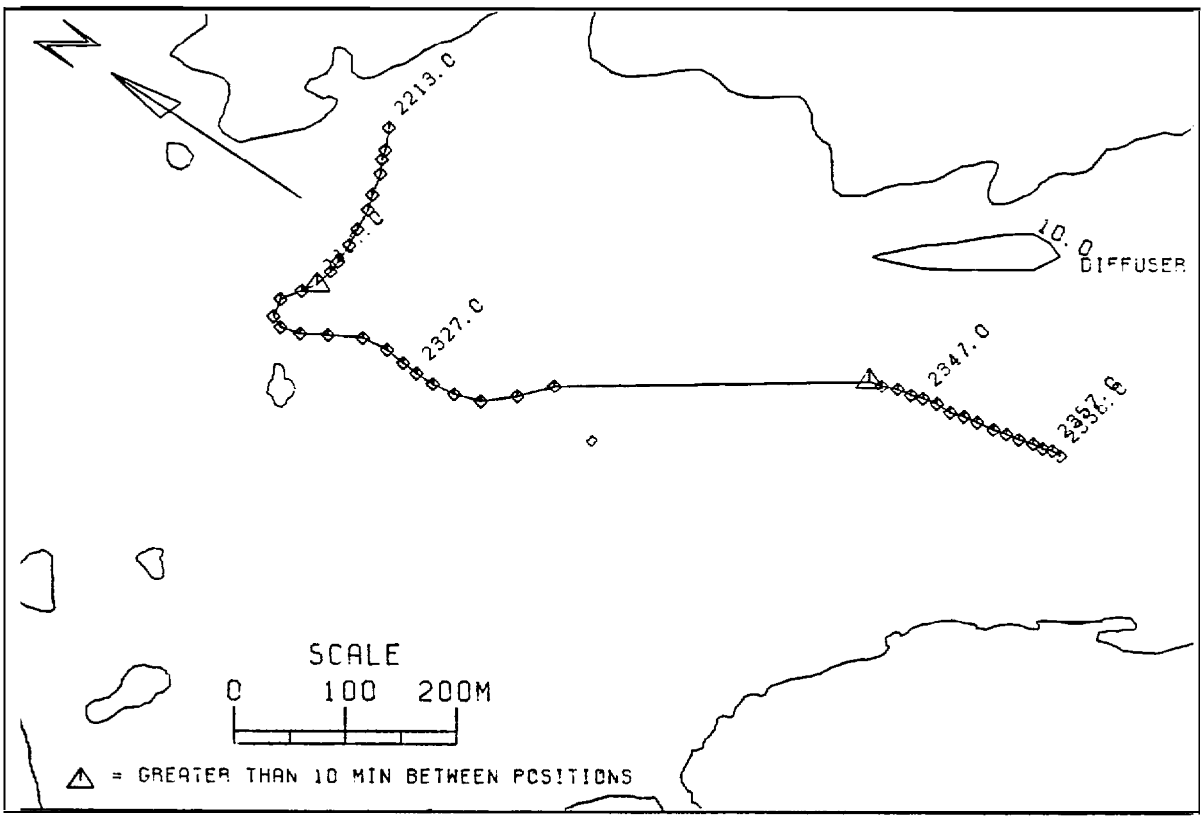
APPENDIX 1

APPENDIX I

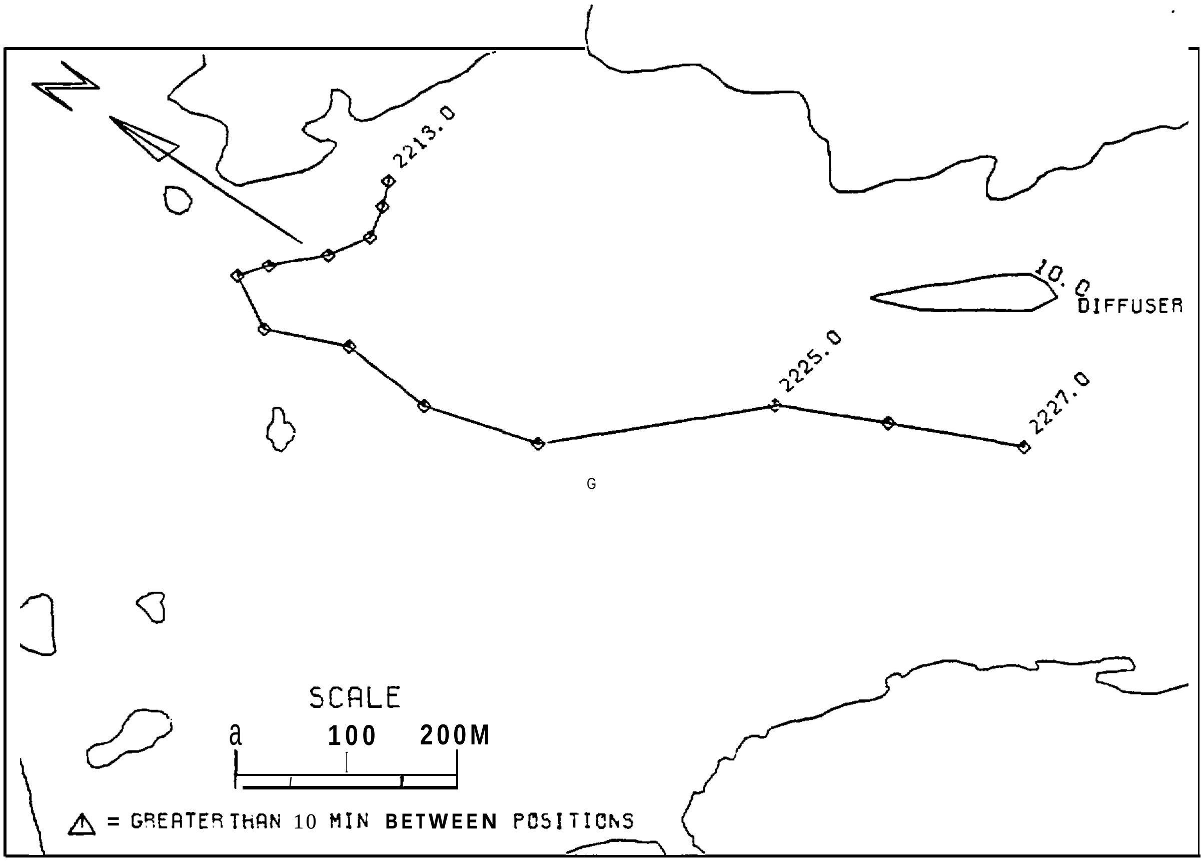
PLOTS OF HORIZONTAL MOVEMENTS OF ADULT PINK SALMON DURING TREATMENT EXPERIMENTS



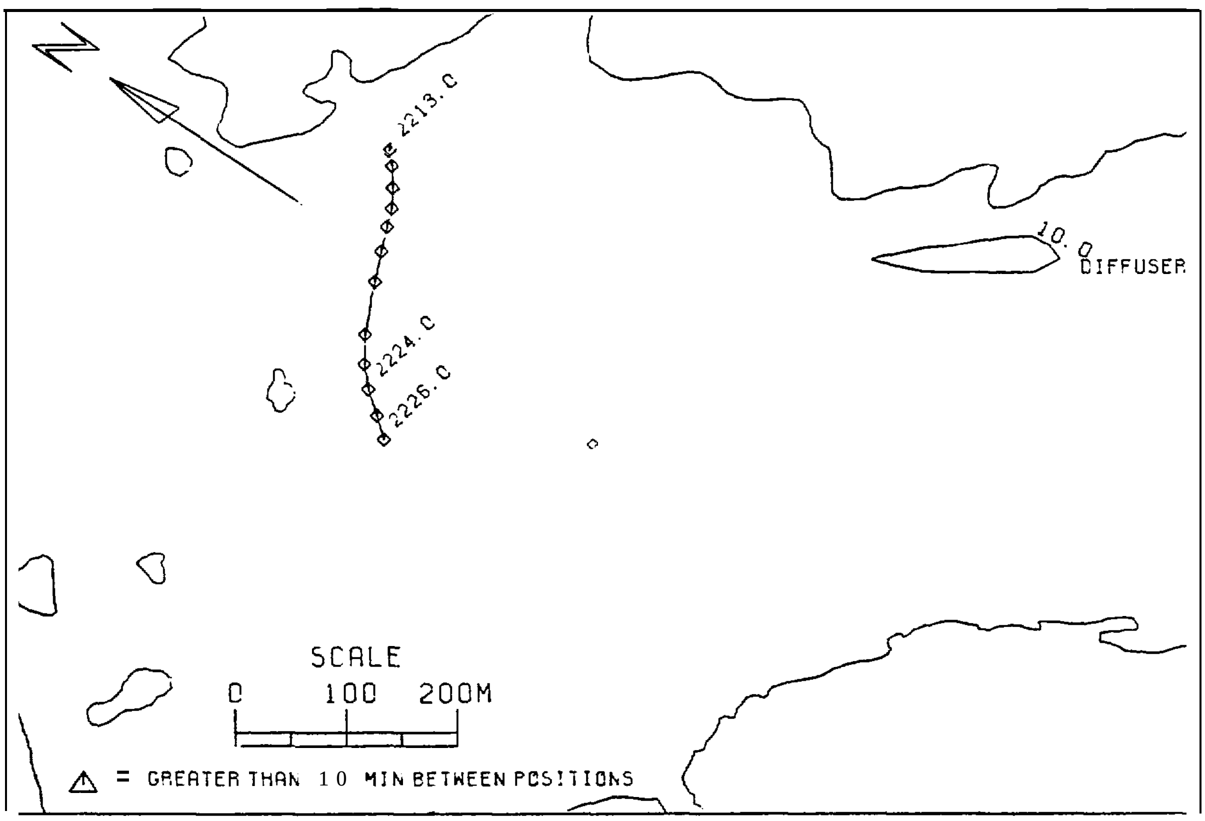
JAKOLOF BAY, FISH 13, TREAT. NO. 1, 7/20/88



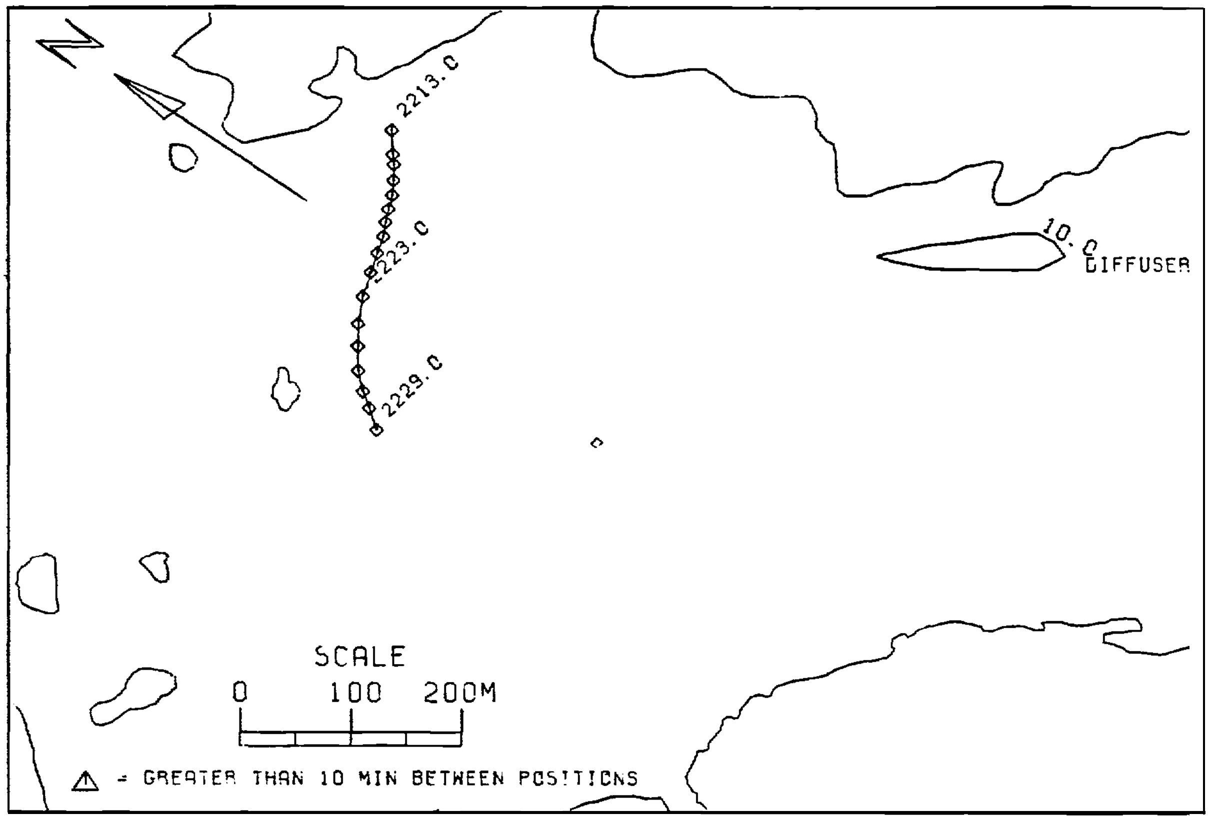
JAKOLOF BAY, FISH 14, TREAT. NO. 1, 7/20/88



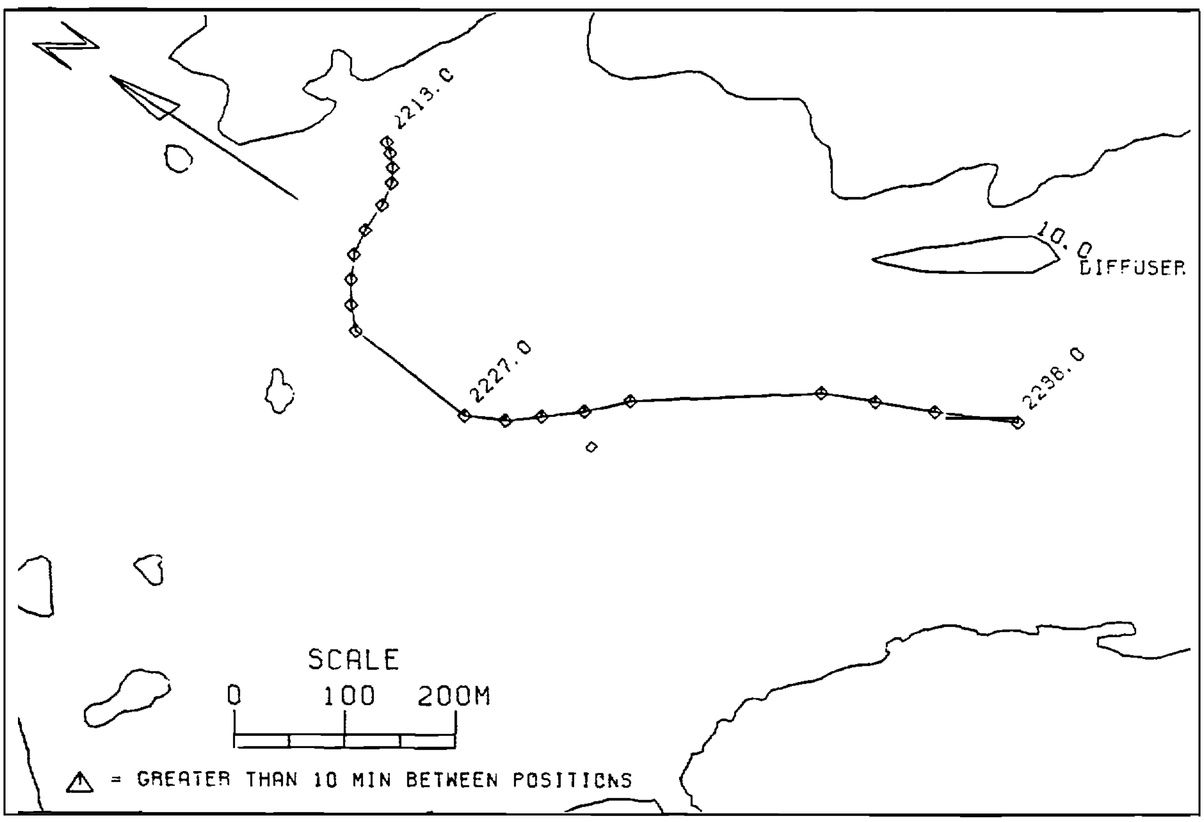
JAKOLOF BAY, FISH 15, TREAT. NO. 1, 7/20/88



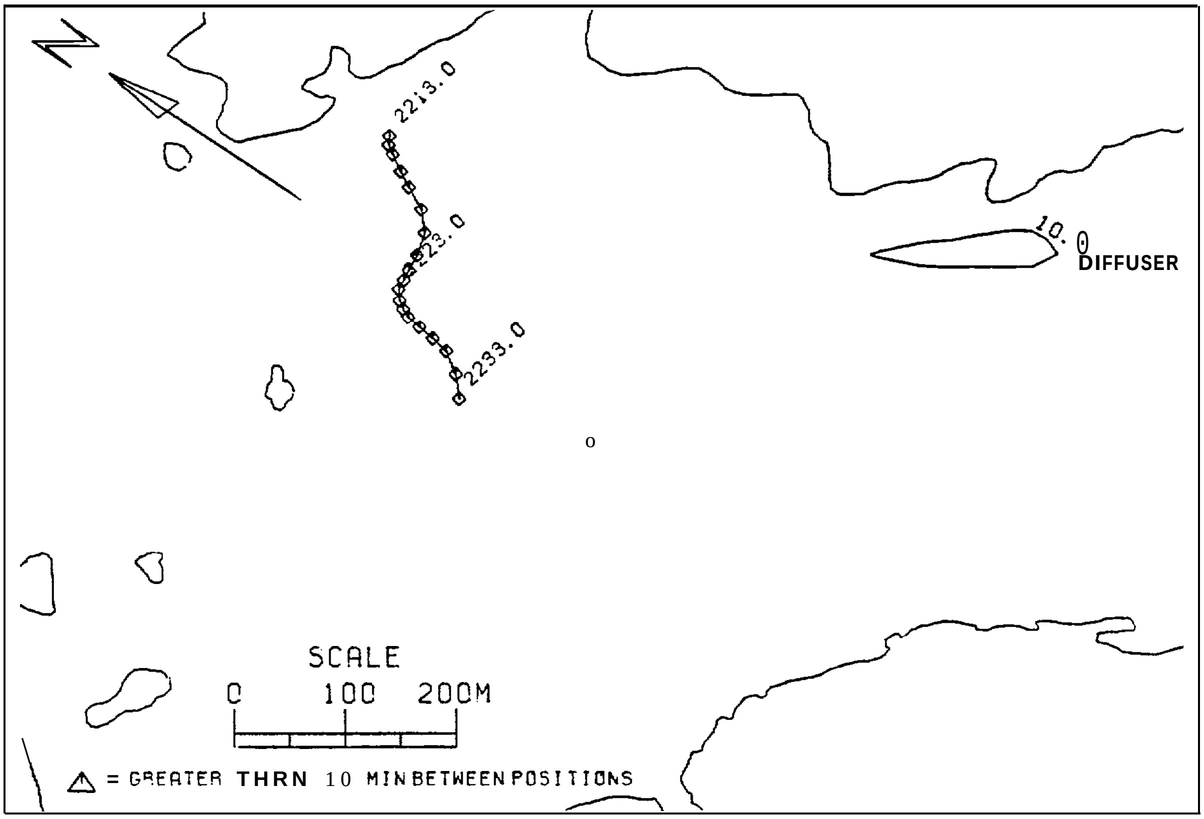
JAKOLOF BAY, FISH 16, TREAT. NO. 1, 7/20/82



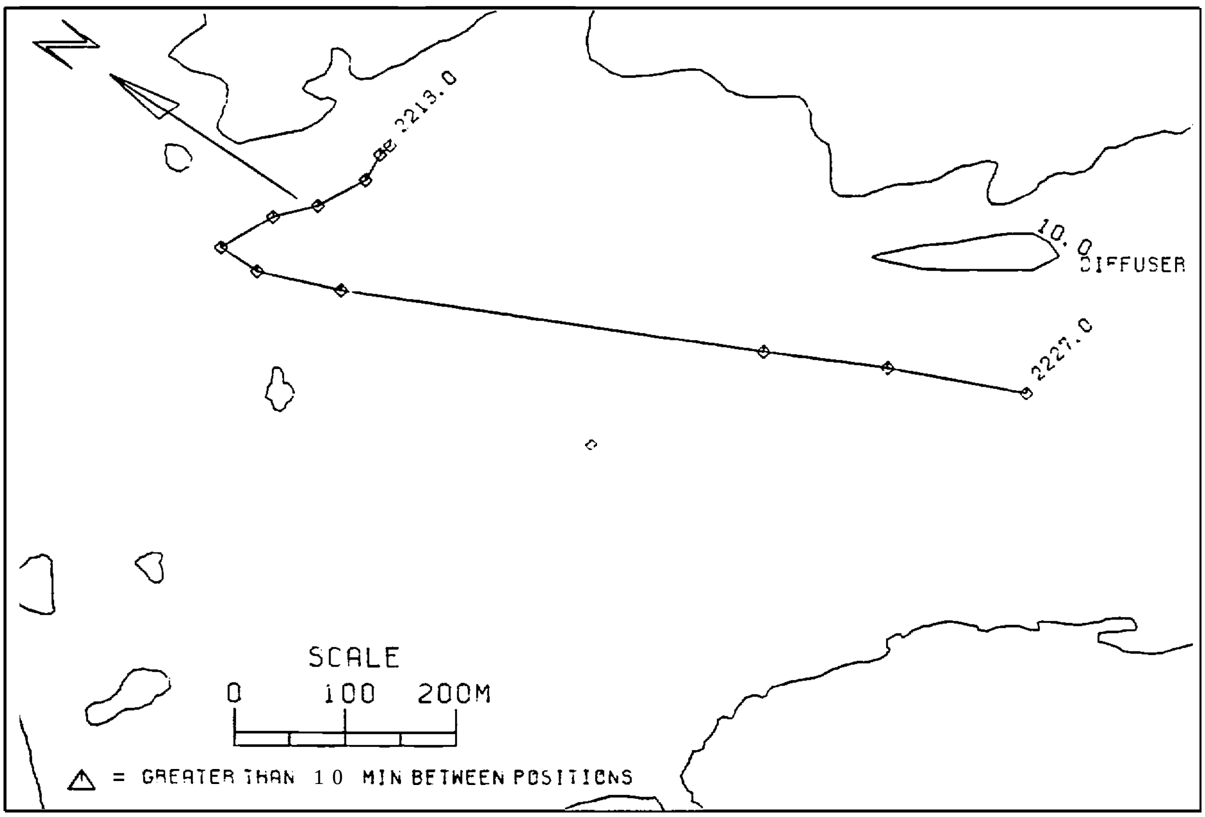
JAKOLOF BAY, FISH 17, TREAT. NO. 1, 7/20/88



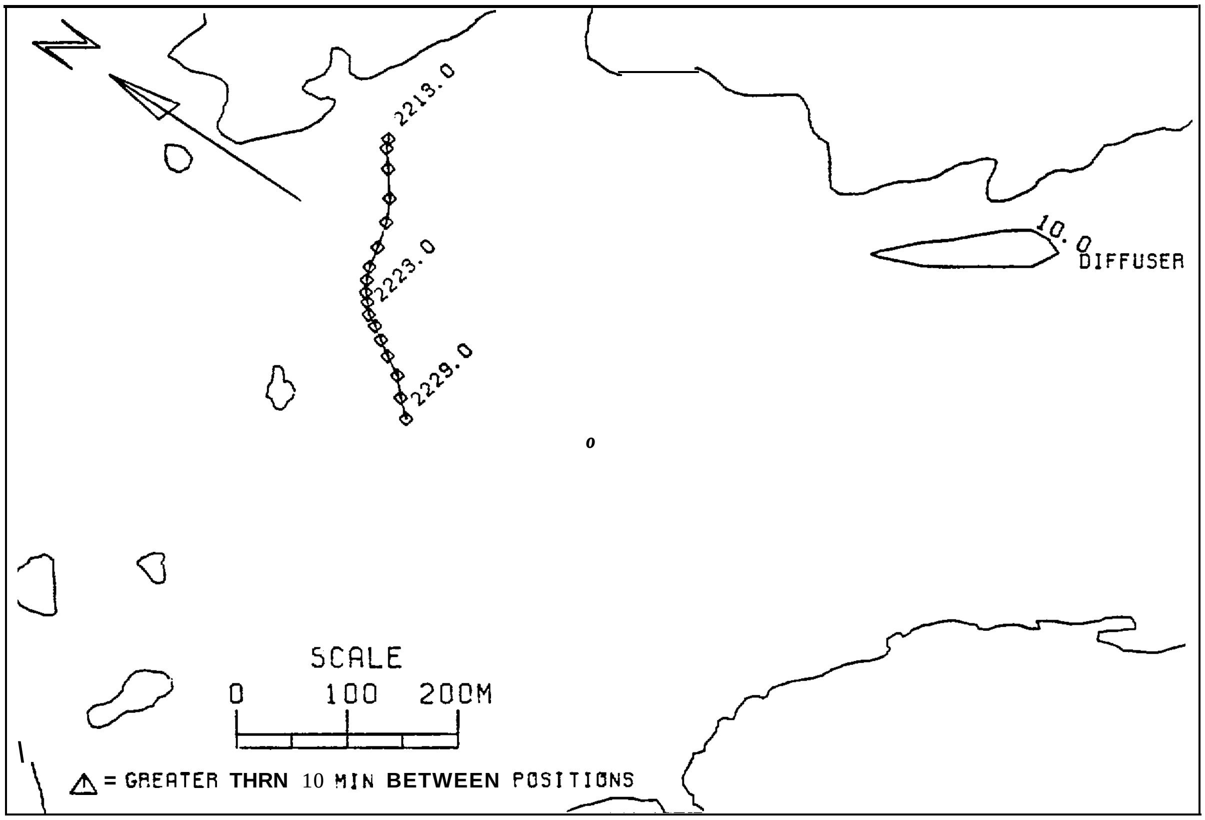
JAKOLOF BAY, FISH 18, TREAT. NO. 1, 7/20/88



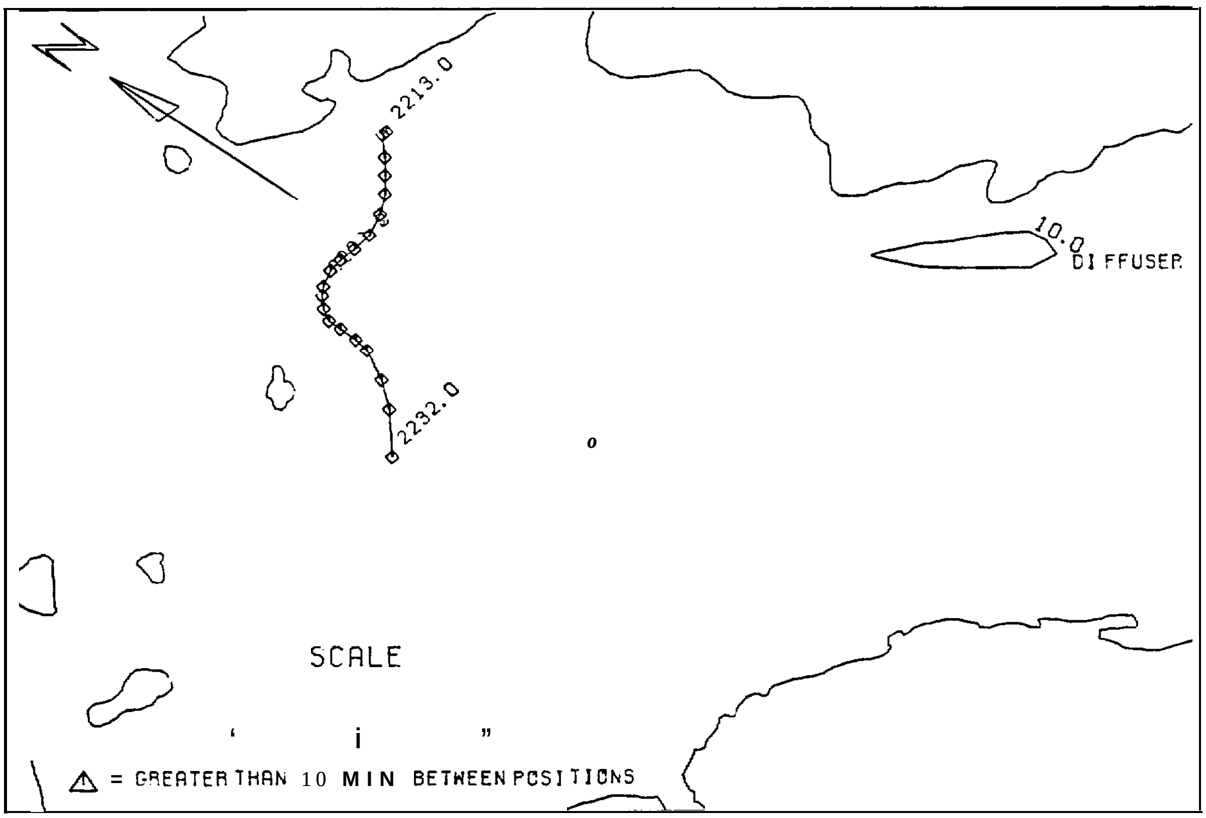
JAKOLOF BAY, FISH 199 TREAT. NO. 1, 7/20/88



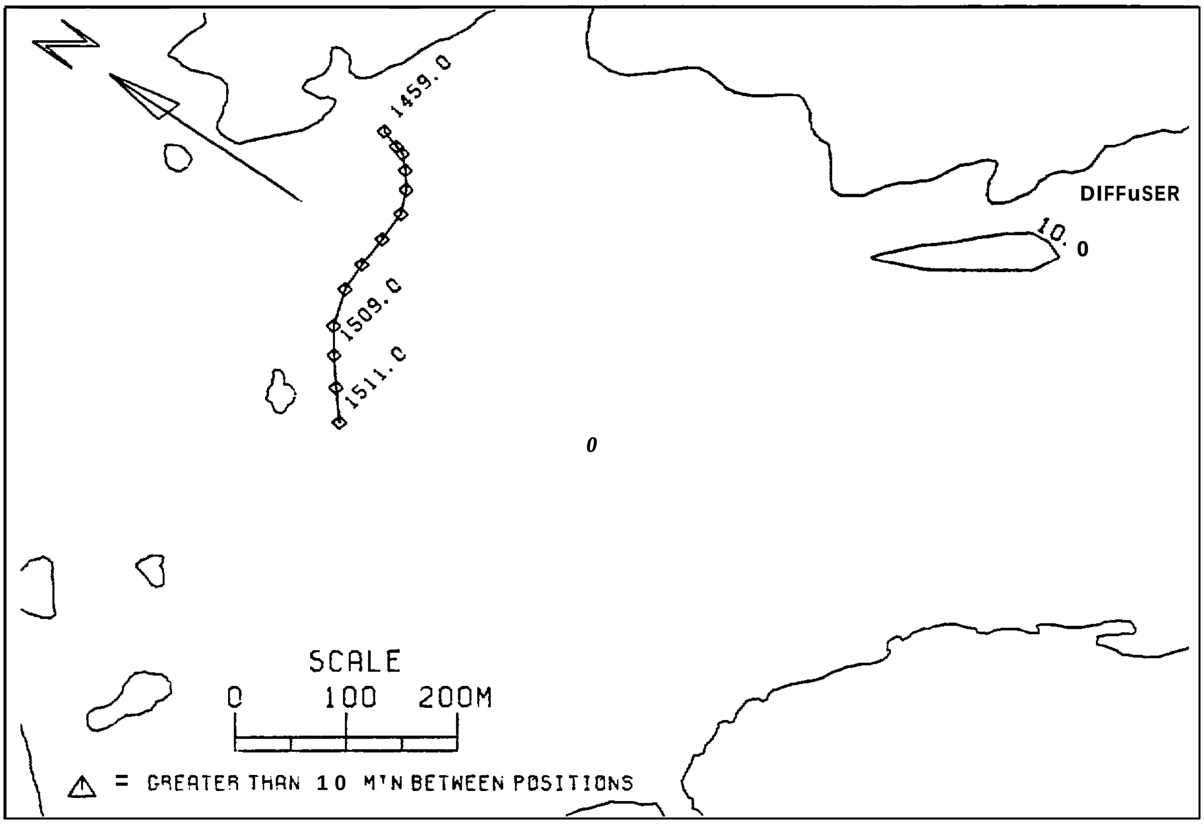
JAKOLOF BAY, FISH 20, TREAT. NO. 1, 7/20/88



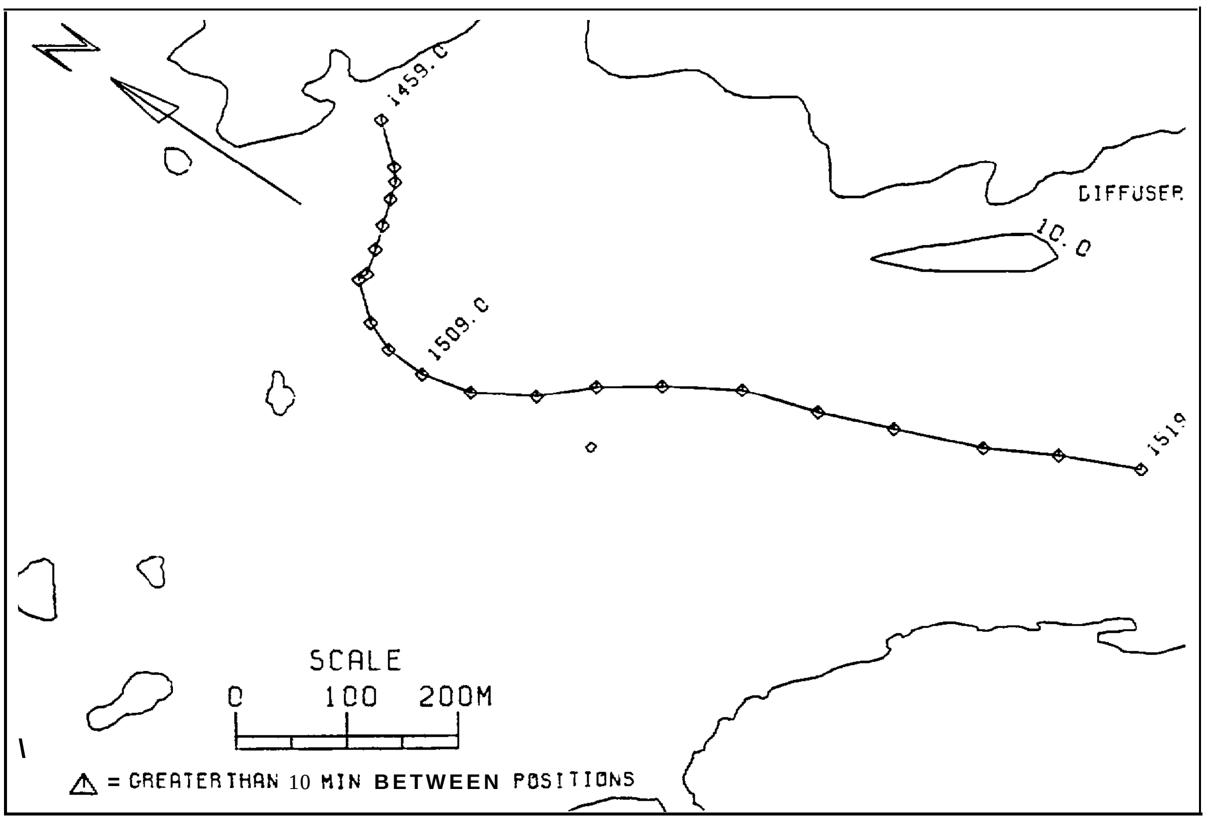
JAKOLOF BAY, FISH 21, TREAT. NO. 1, 7/20/88



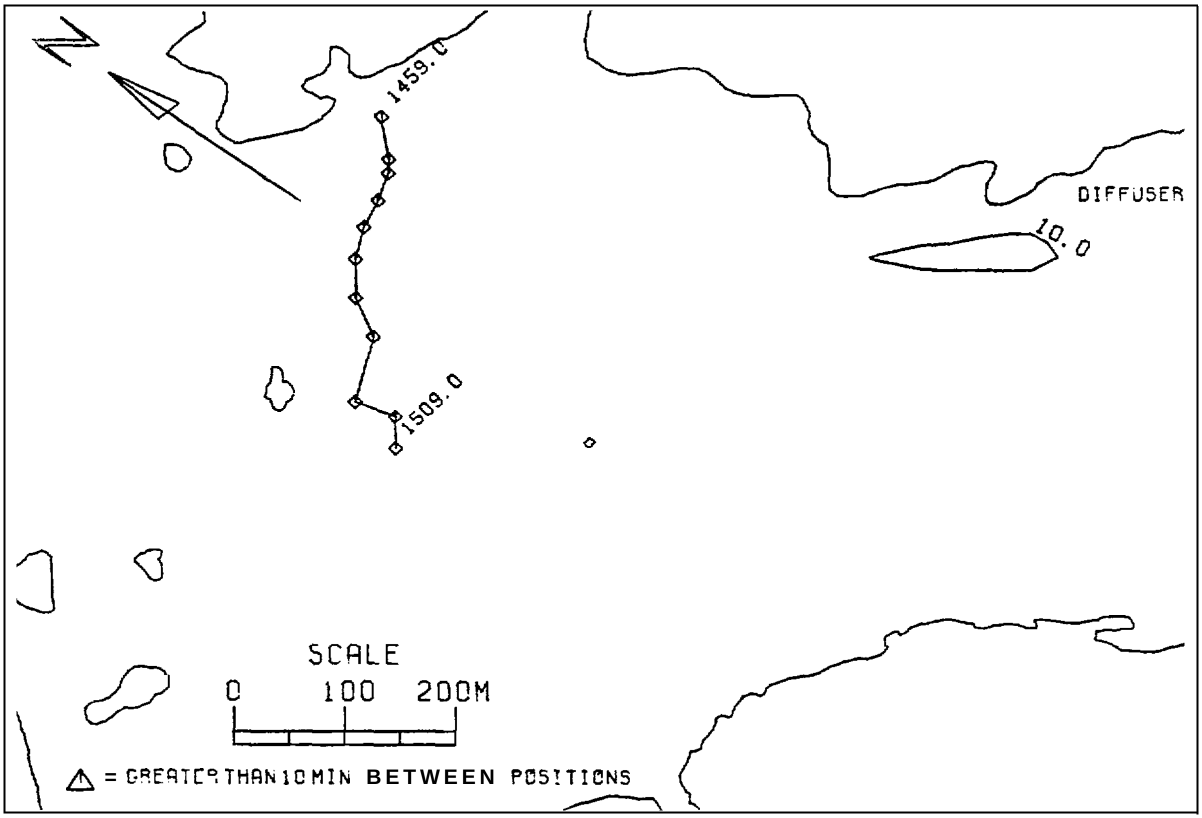
JAKOLOF BAY, FISH 22, TREAT. NO. 1, 7/20/88



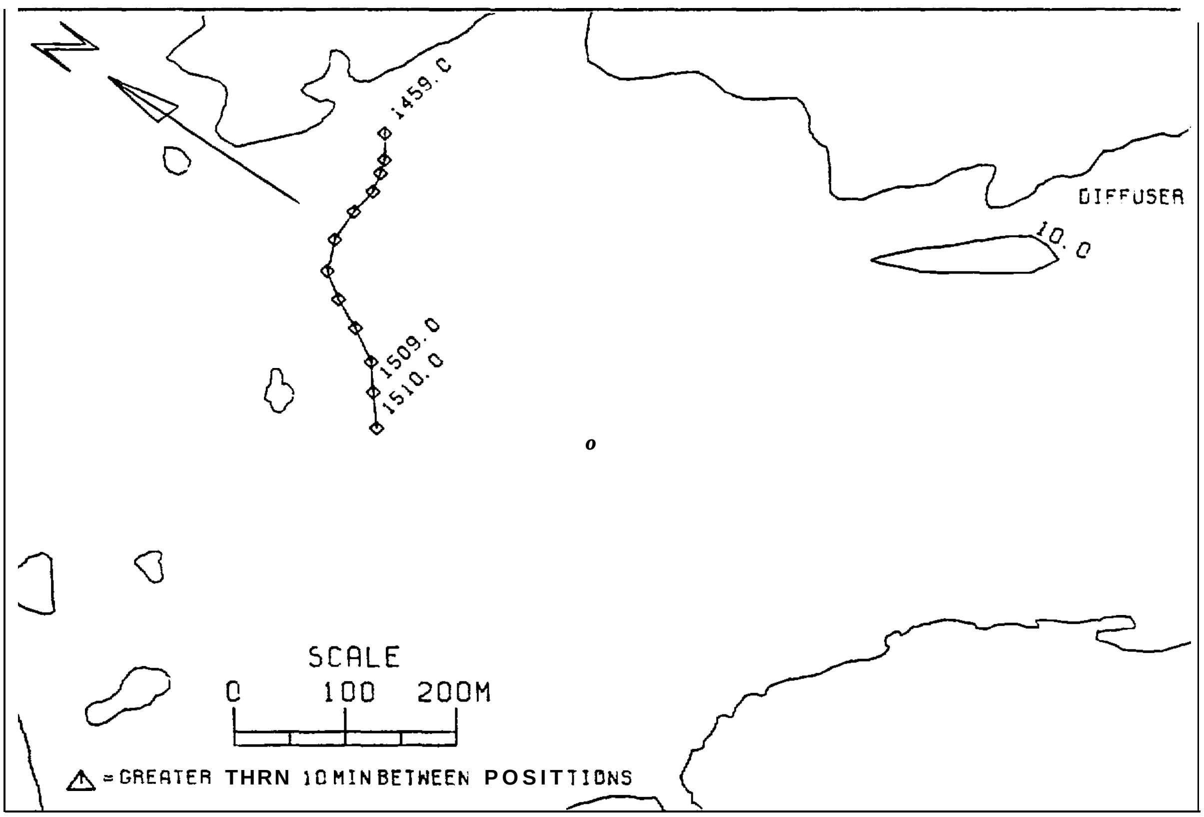
JAKOLOF BAY, FISH 43, TREAT. NO. 2. 7/25/88



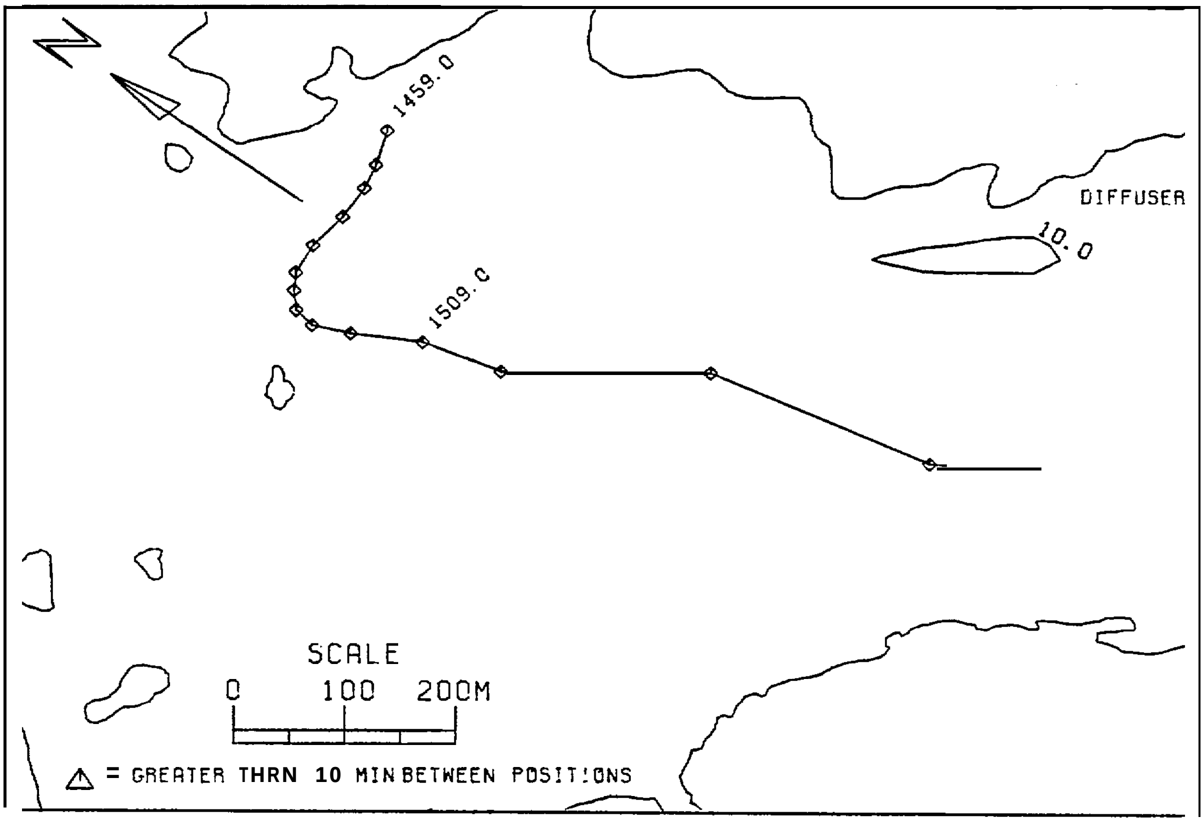
JAKOLOF BAY. FISH 44. TREAT. NO. 2, 7/25/88



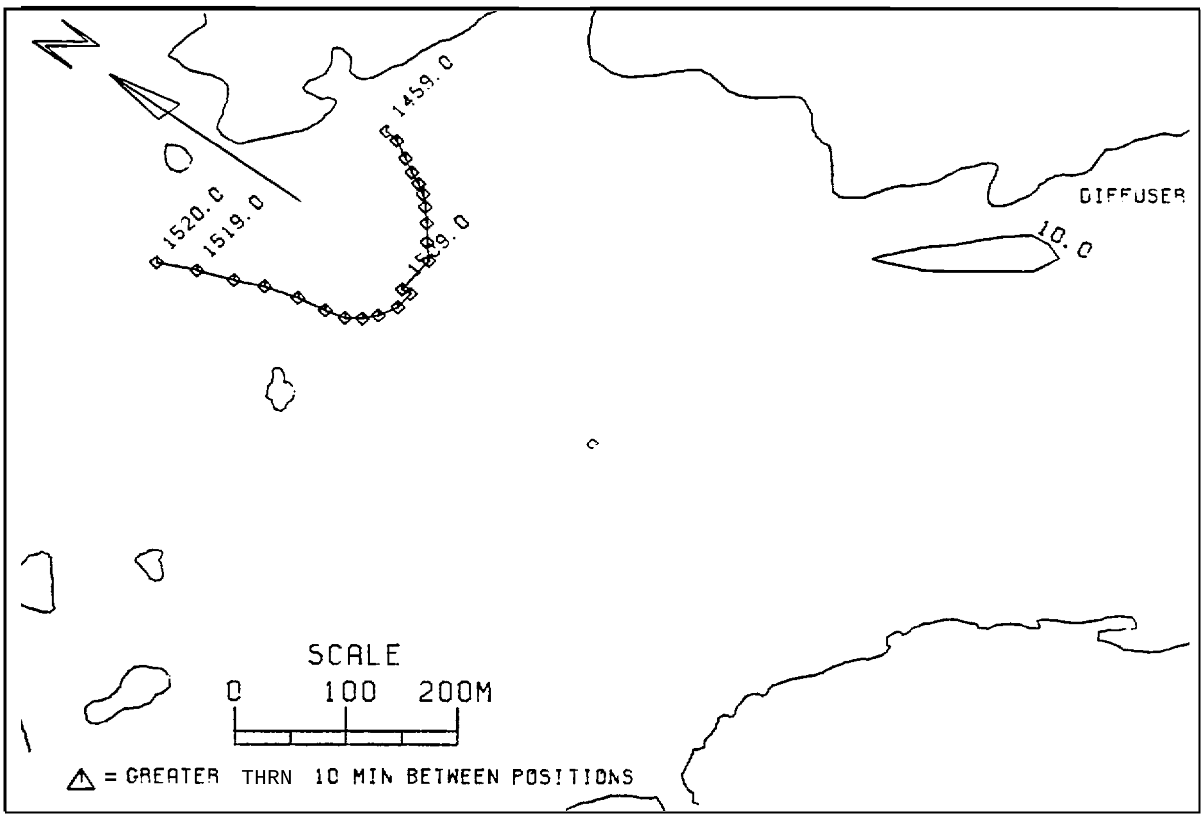
JA KO LOF BA Y, FISH 45, IRE FIT. NO. 2, 7/25/88



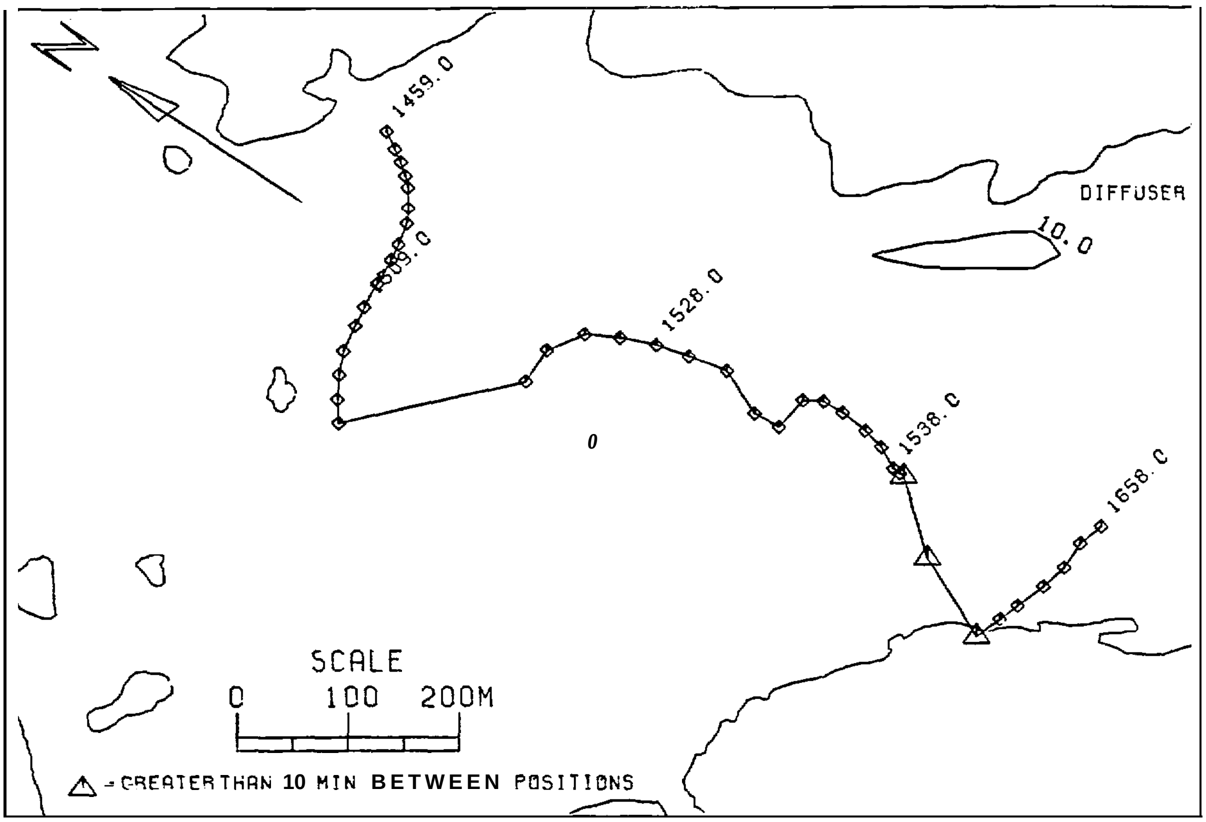
JA KOLOF BAY, FISH 46, TREAT. NO. 2, 7/25/88



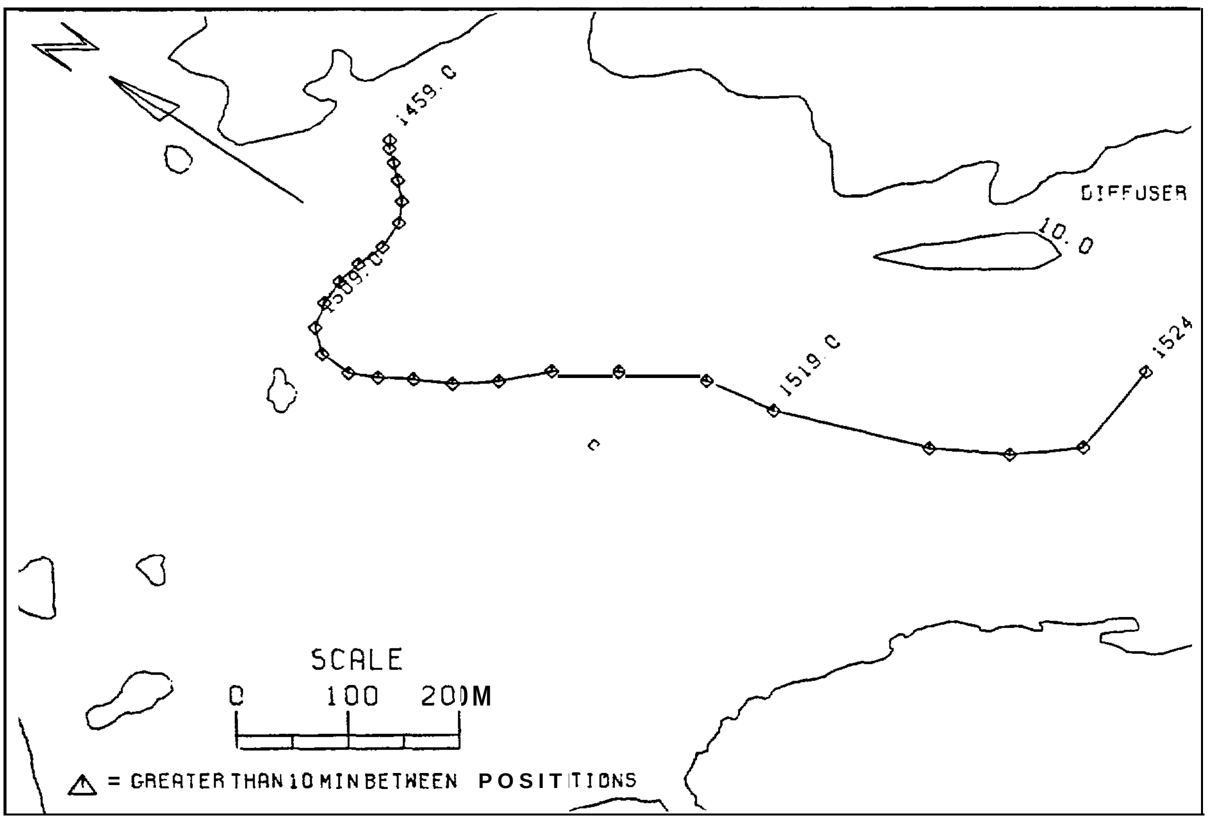
JAKOLOF BAY, FISH 47, TREAT. NO. 2, 7/25/88



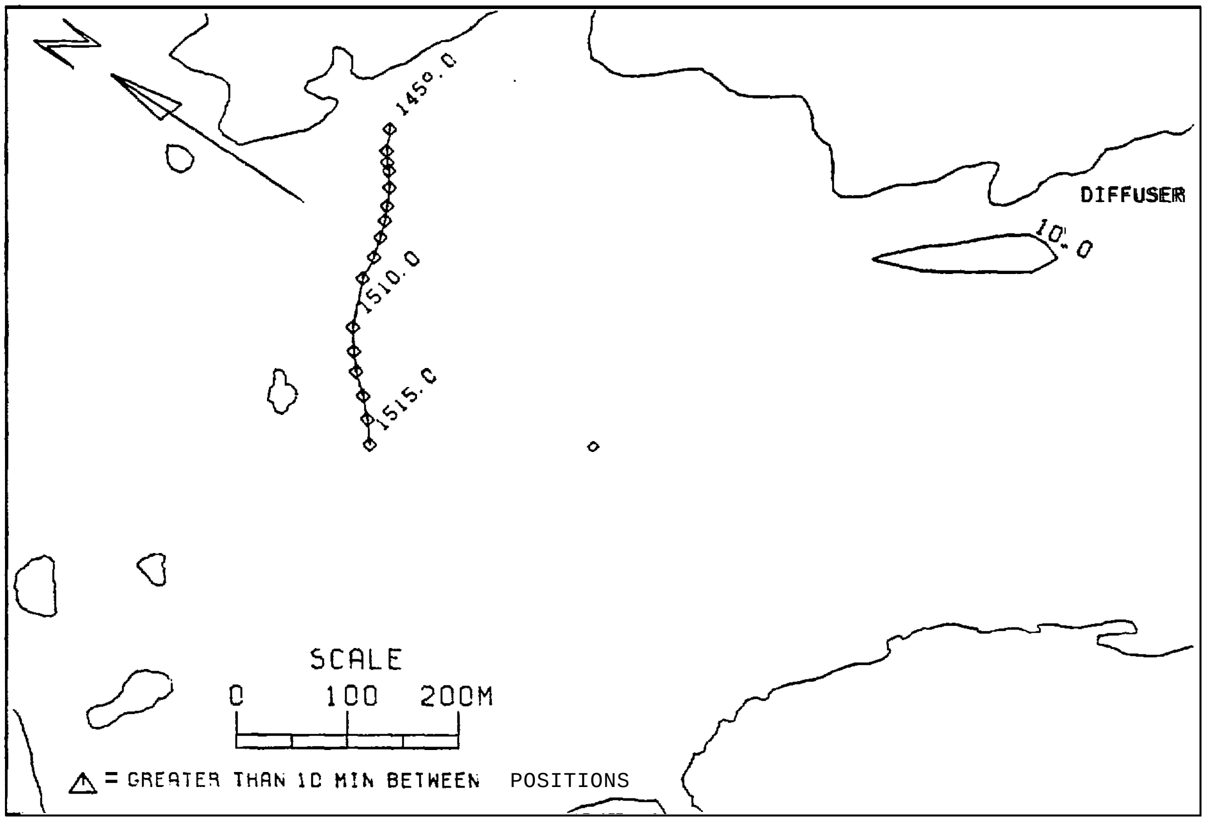
JAKOLOF BAY, FISH 48. TREAT. NO. 2, 7/25/88



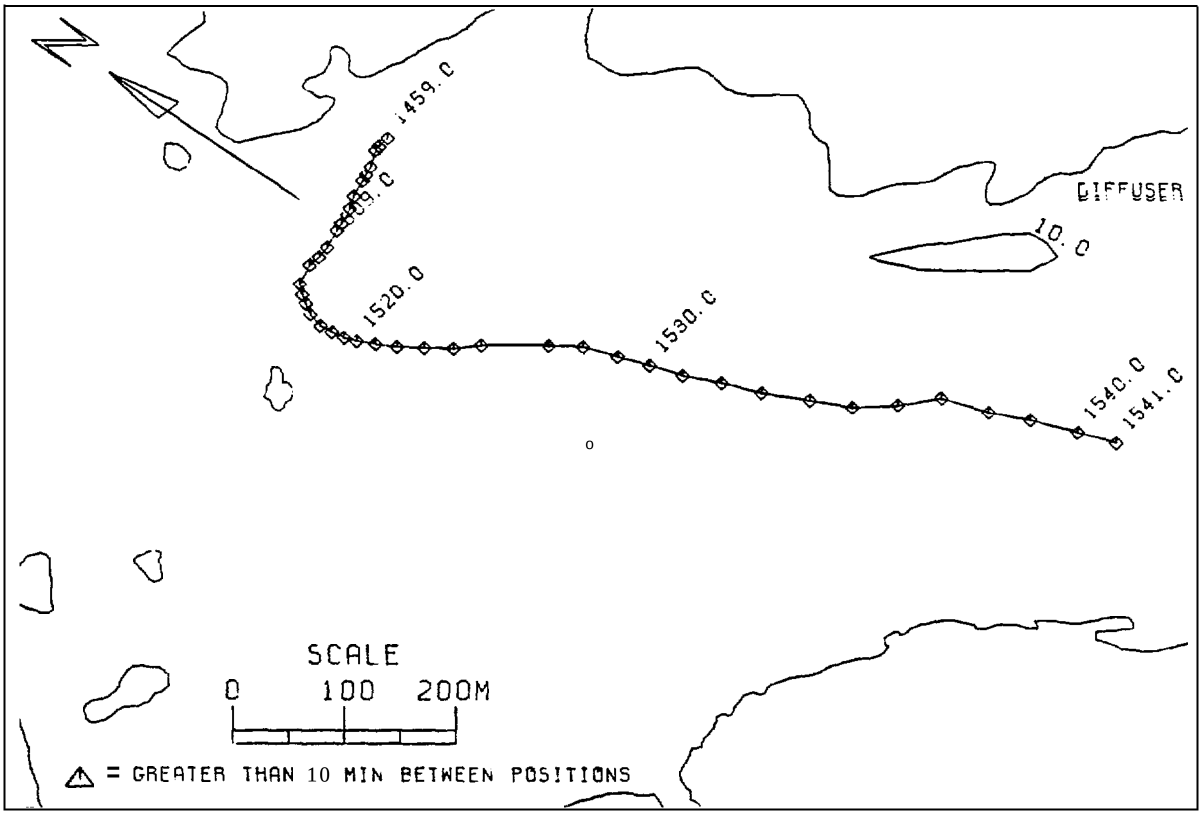
JAKOLOF BAY, FISH 49, TREAT. NO. 2, 7/25/88



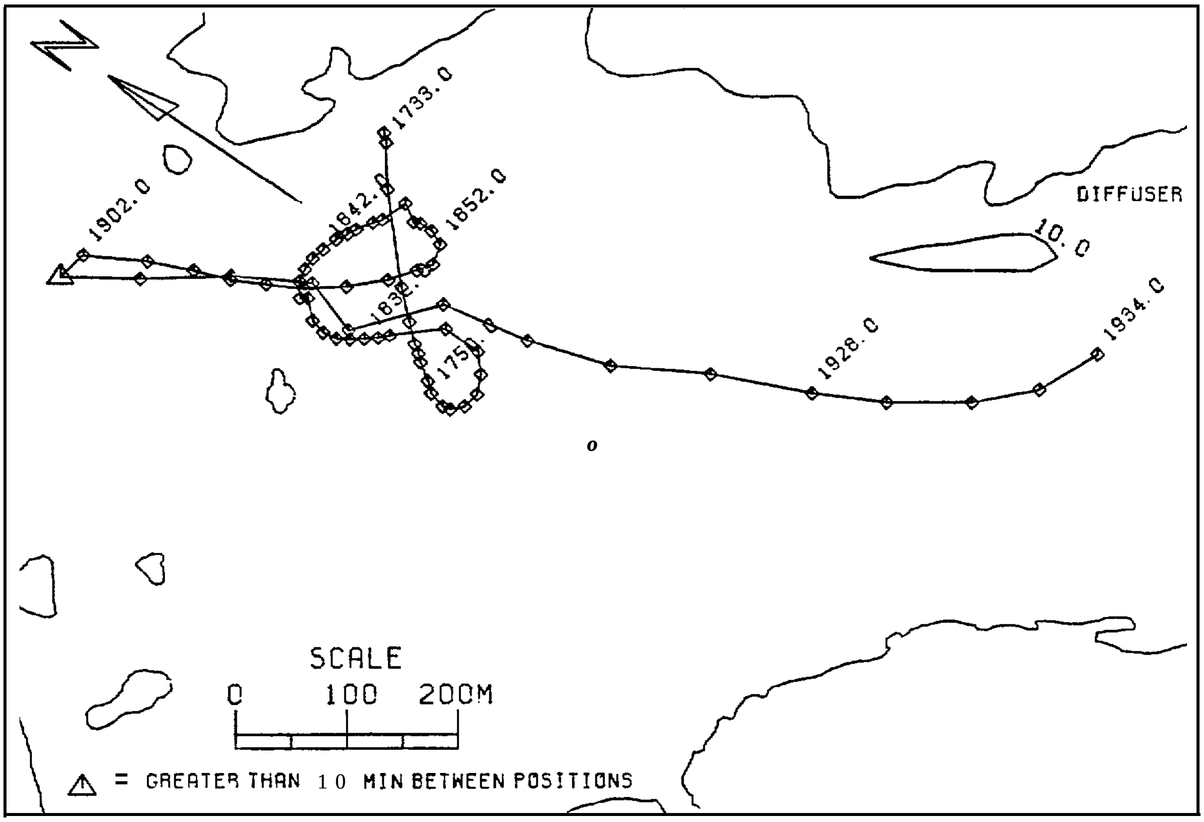
JAKOLOF BAY, FISH 50, TREAT. NO.2, 7/25/88



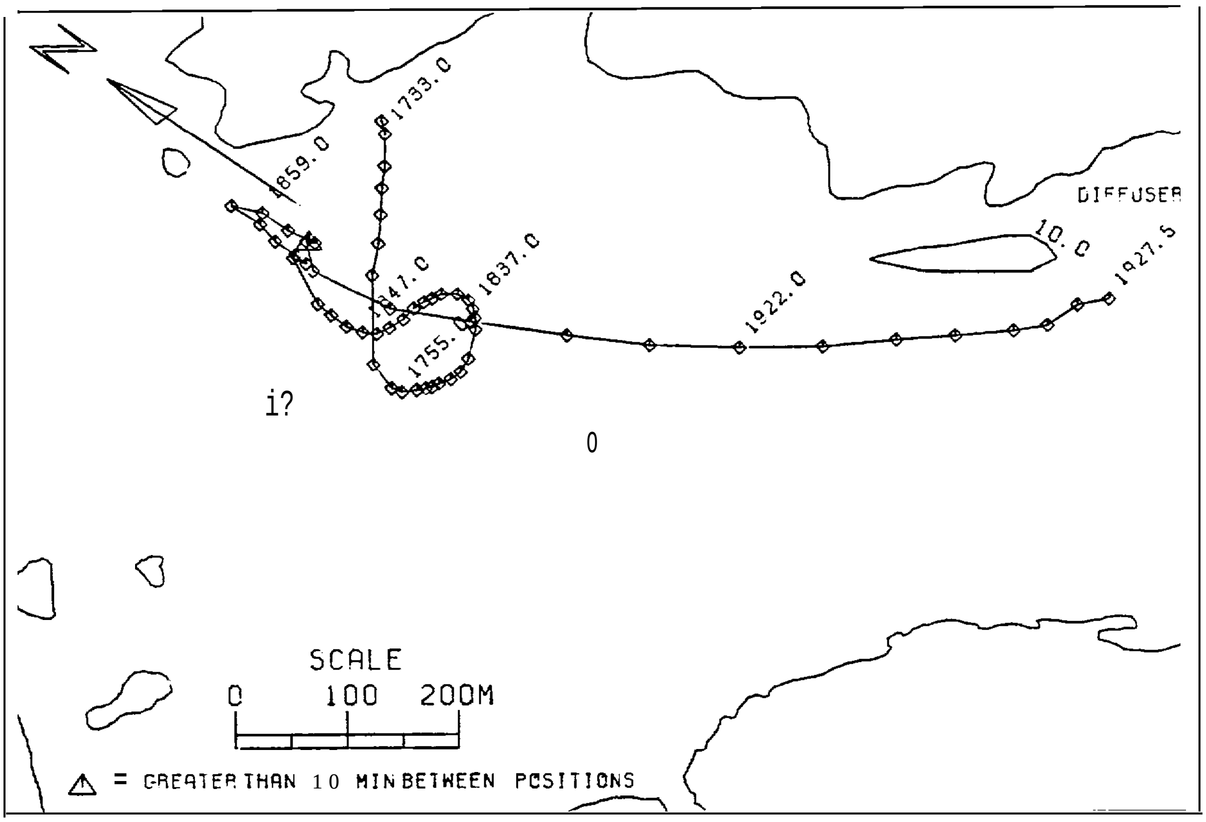
JAKOLOF BA Y, FISH 51, TREAT. NO. 2, 7/25/'88



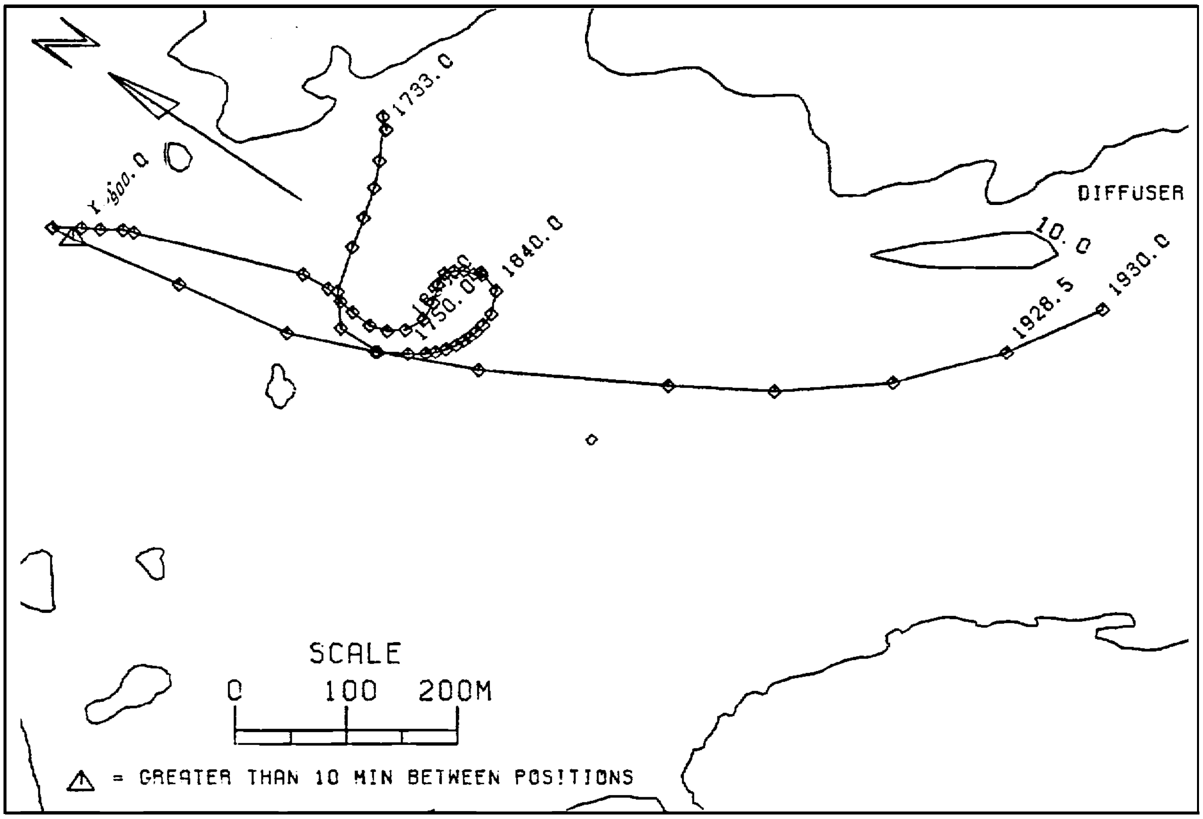
JAKOLOF BAY, FISH 52, TREA T. NO. 2, 7/25/88



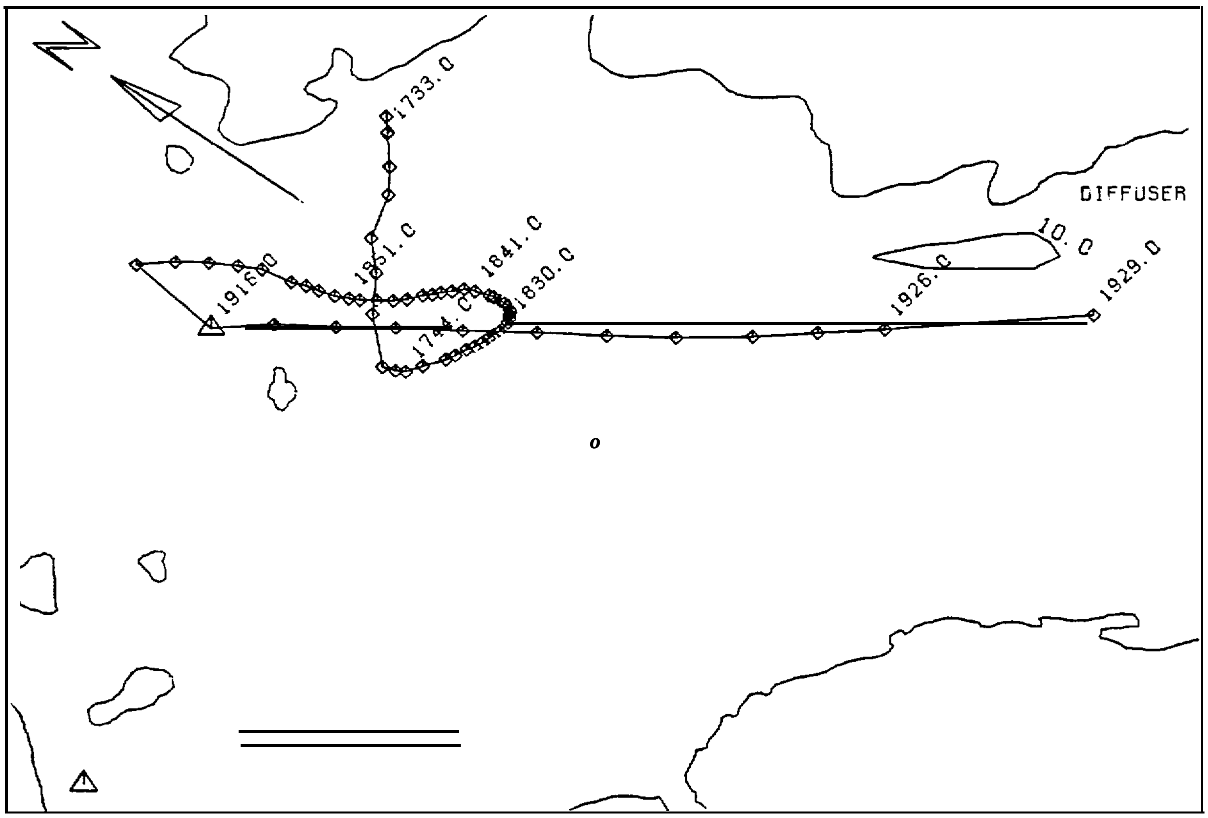
JA KOLOF BAY, FISH 73, TREAT. NO. 3, 7/29/88



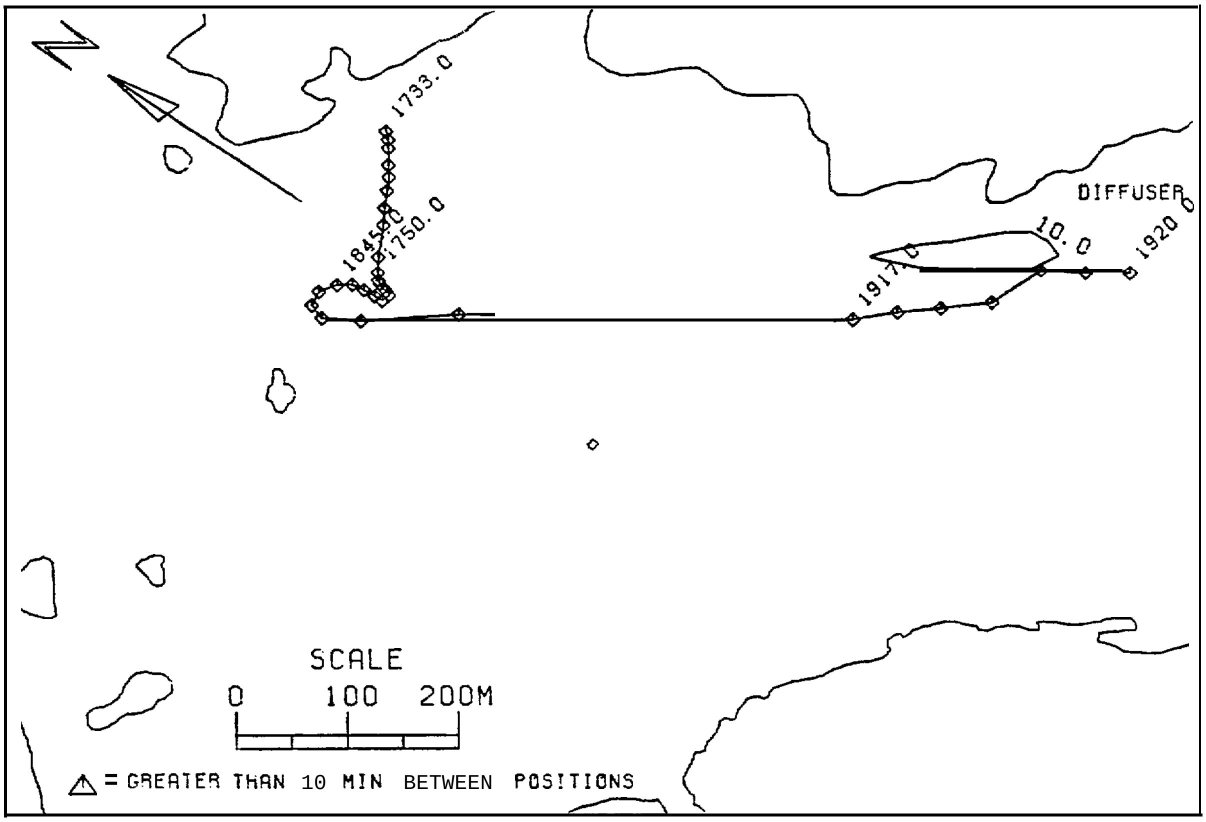
JA KOLOF BAY, FISH 74, TREAT. NO. 3, 7/29/88



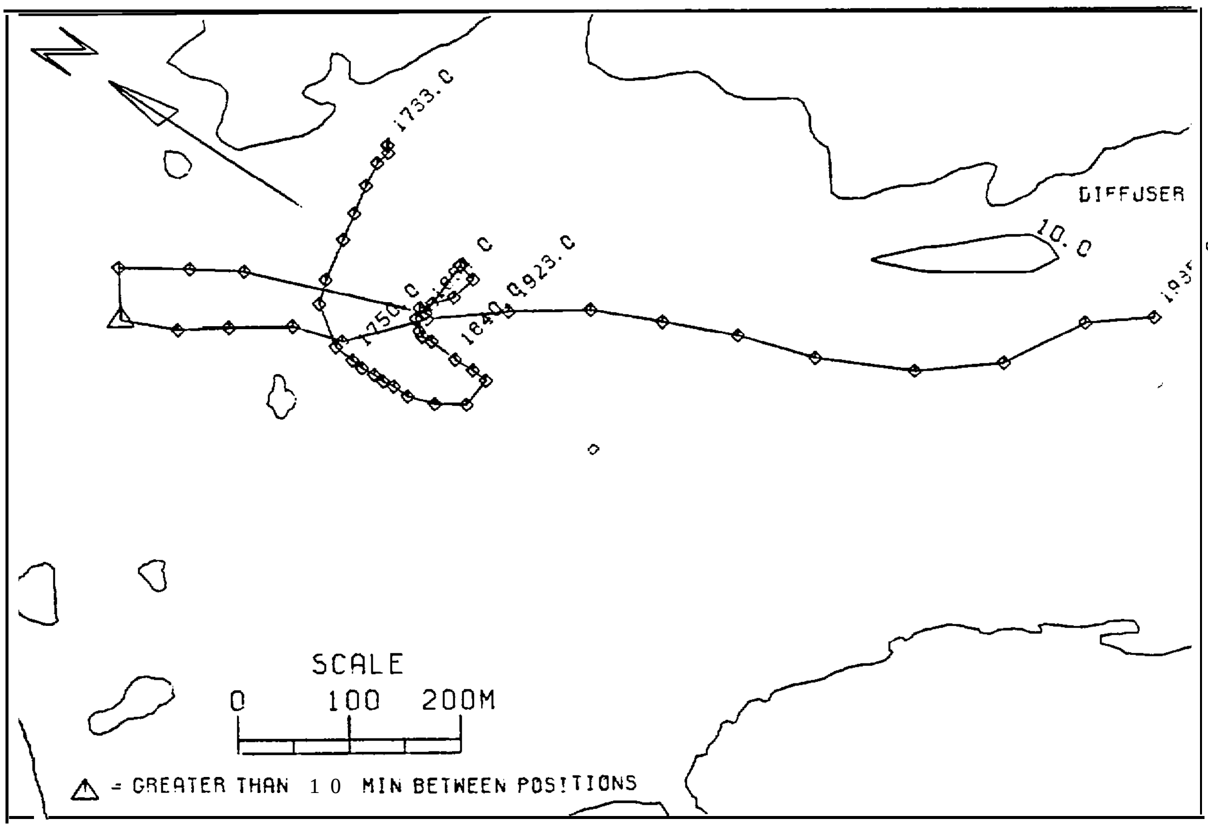
JAKOLOF BAY, FISH 75, TREAT. NO. 3, 7/29/88



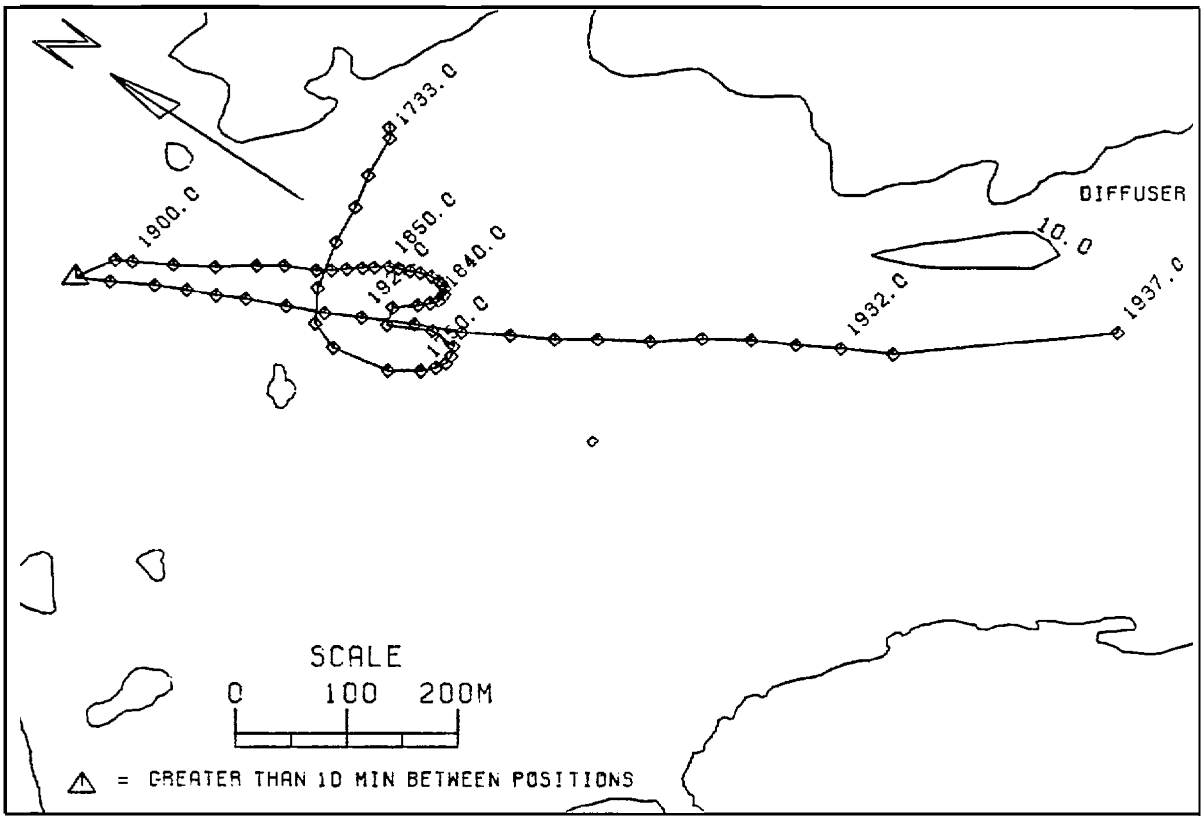
JA KOLOF BAY, FISH 76, TREAT. NO. 3, 7/29/88



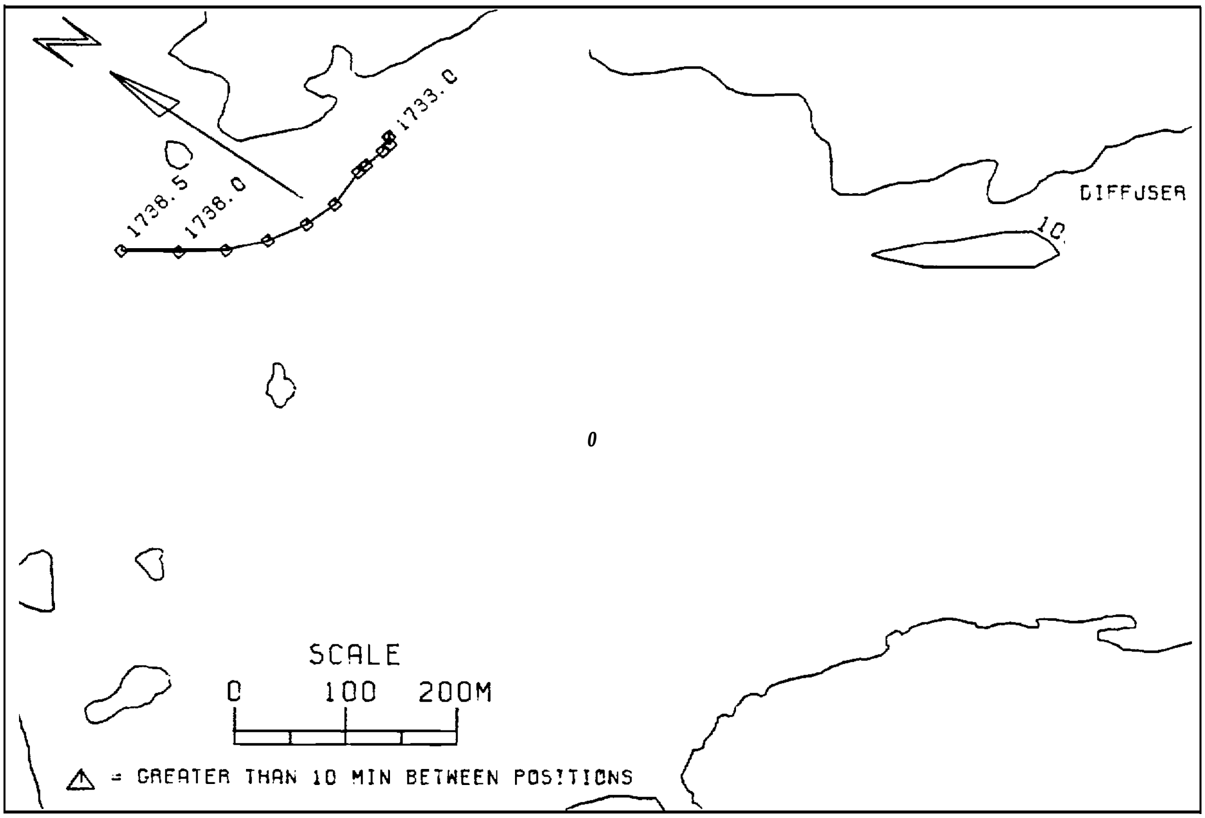
JA KOLOF BAY, FISH 77, TREAT. NO. 3, 7/29/88



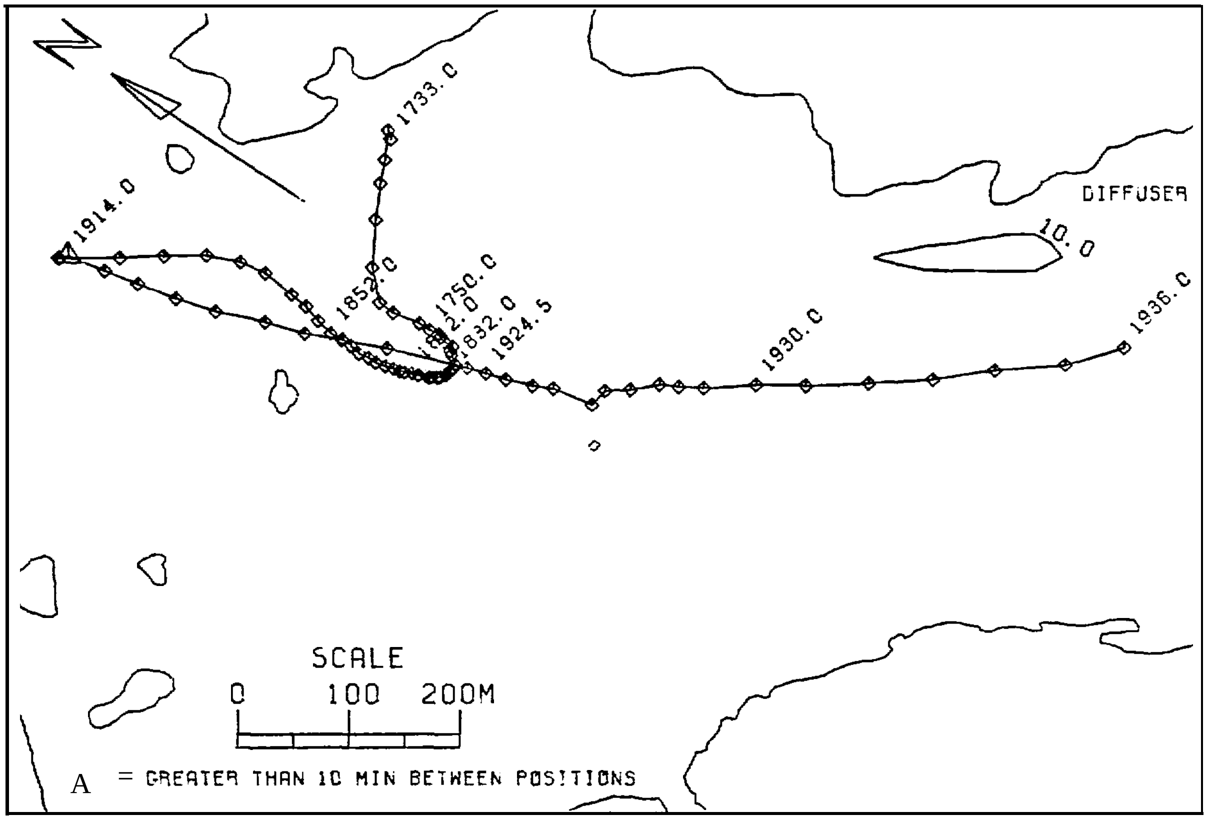
JA KOLOF BAY, FISH 78, TREAT. NO. 3, 7/29/88



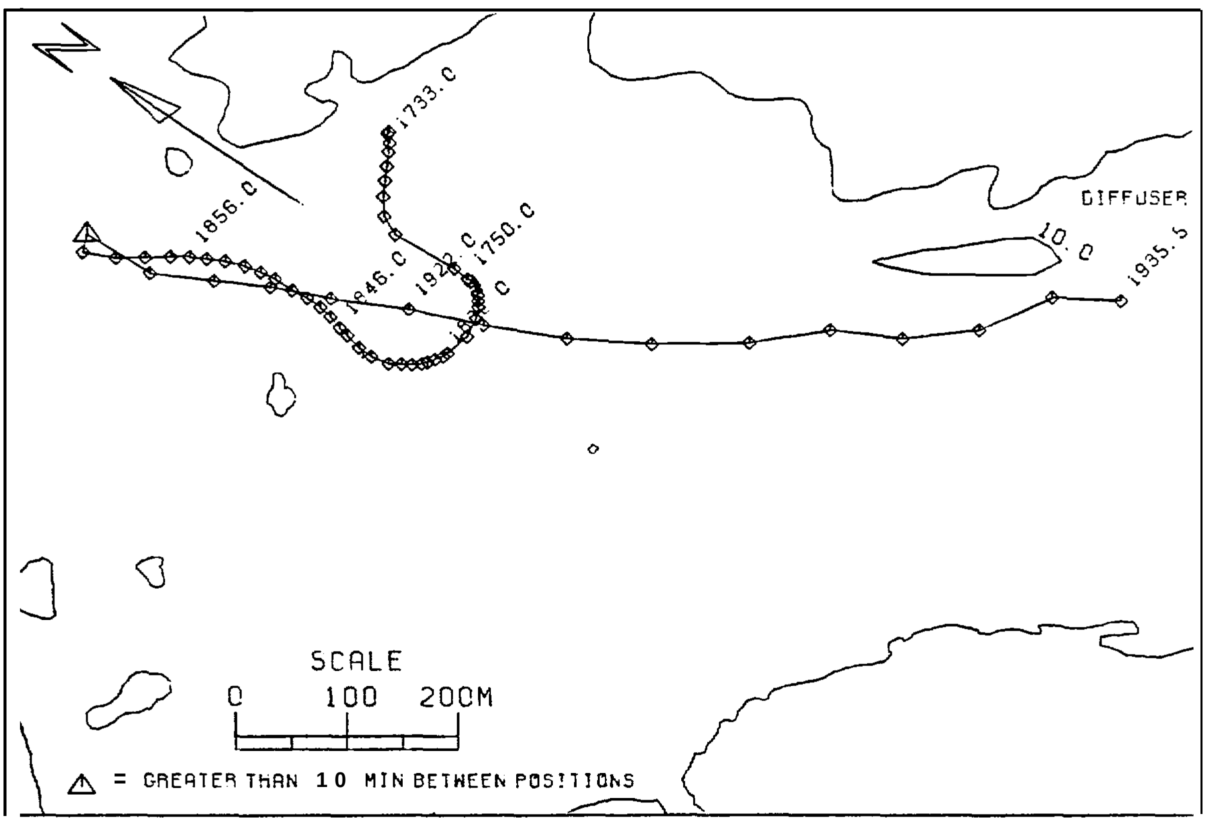
JAKOLOF BAY, FISH 79, TREA T. NO. 3, 7/29/88



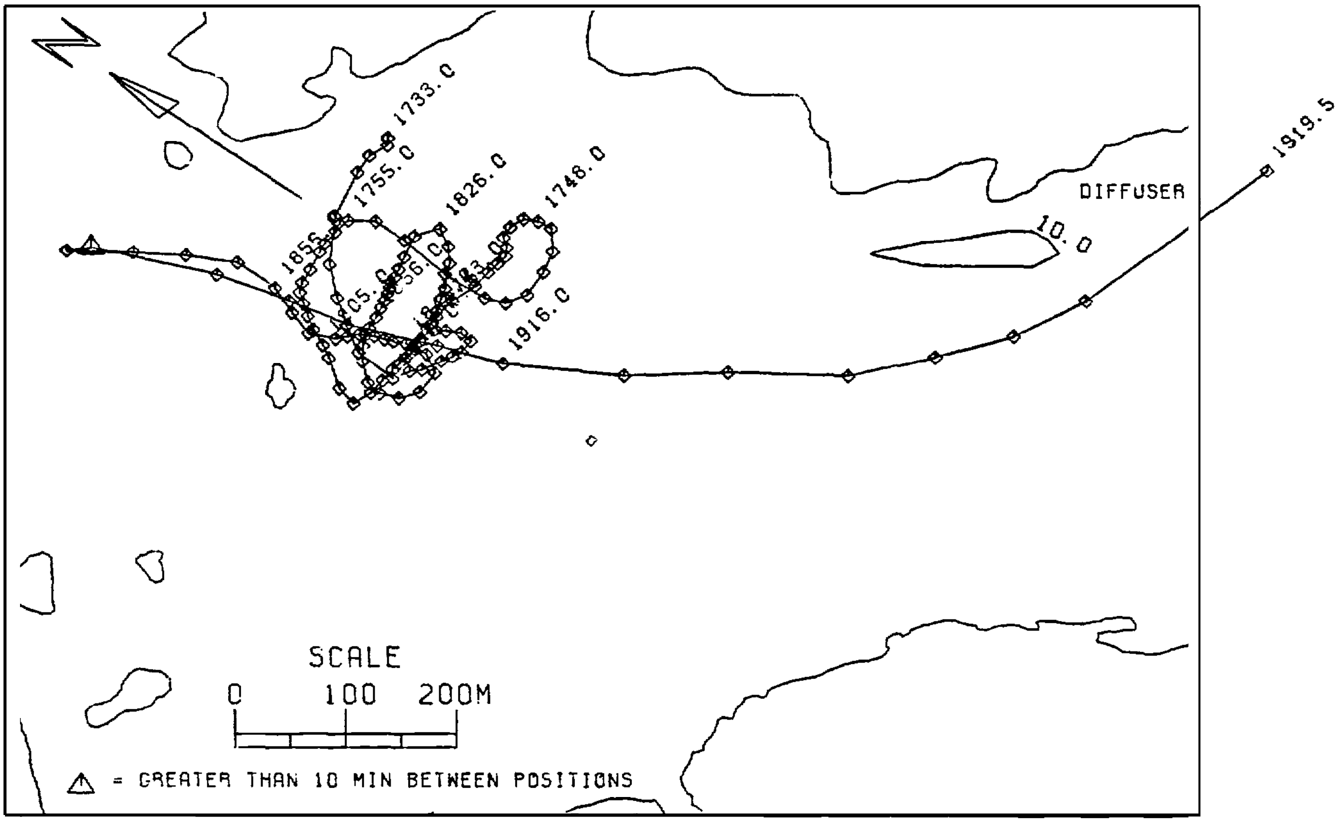
JAKOLOF BAY, FISH 80, TREAT. NO. 3, 7/29/88



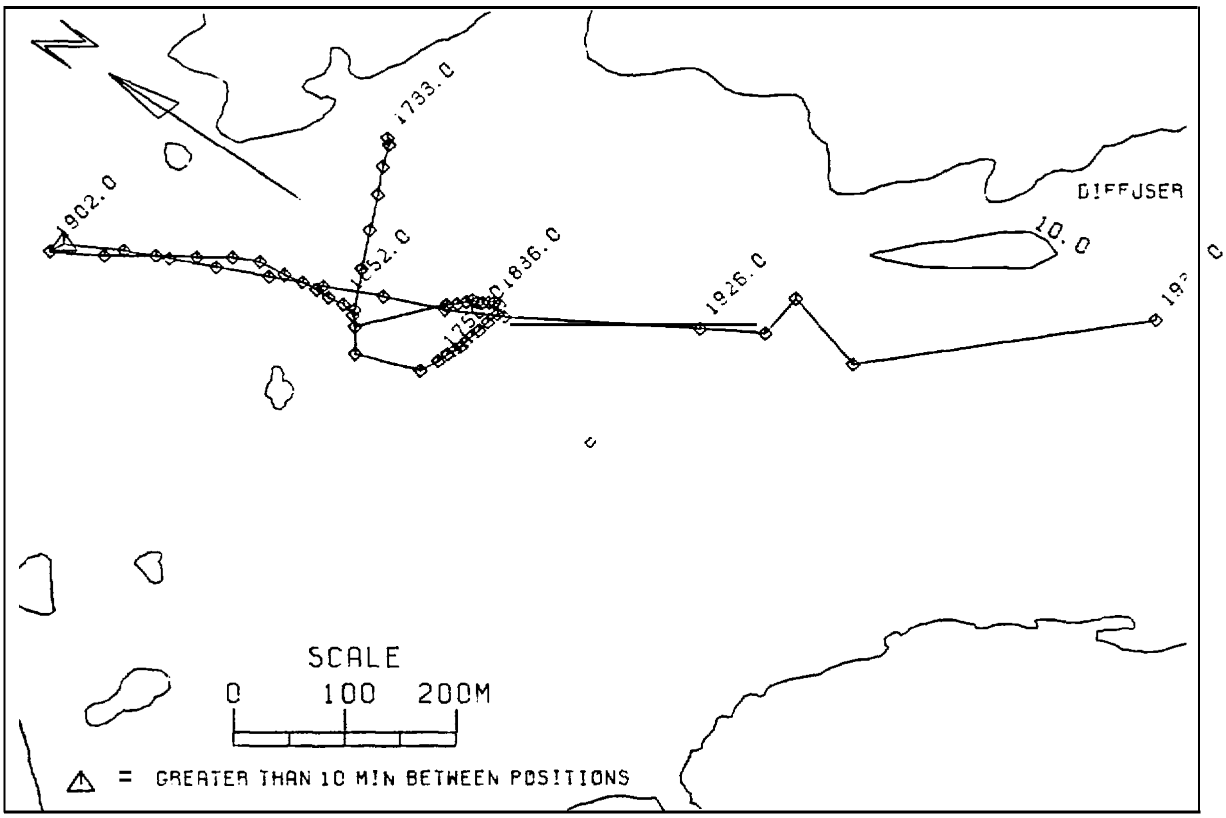
JA KOLOF BAY, FISH 81, TREAT. NO. 3, 7/29/88



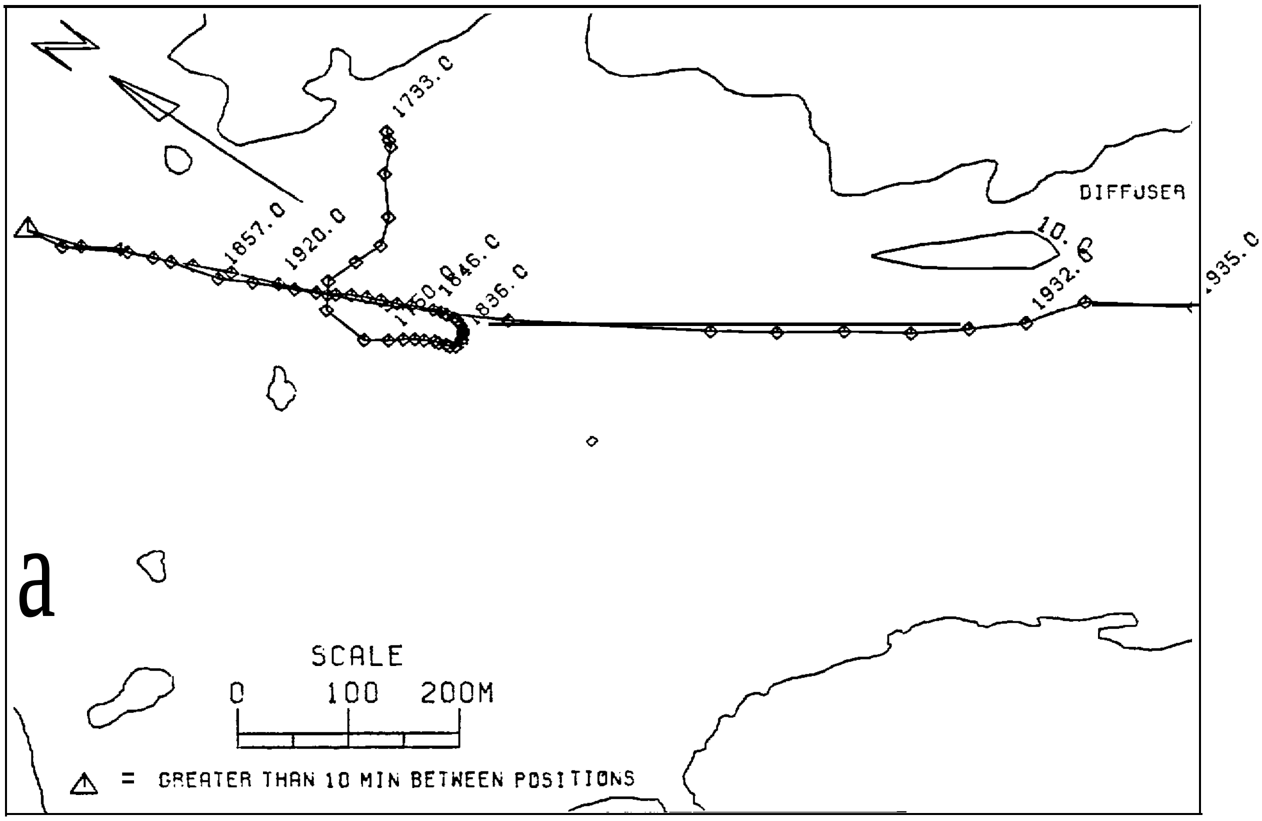
JAKOLOF BAY, FISH 82, TREAT. NO. 3, 7/29/88



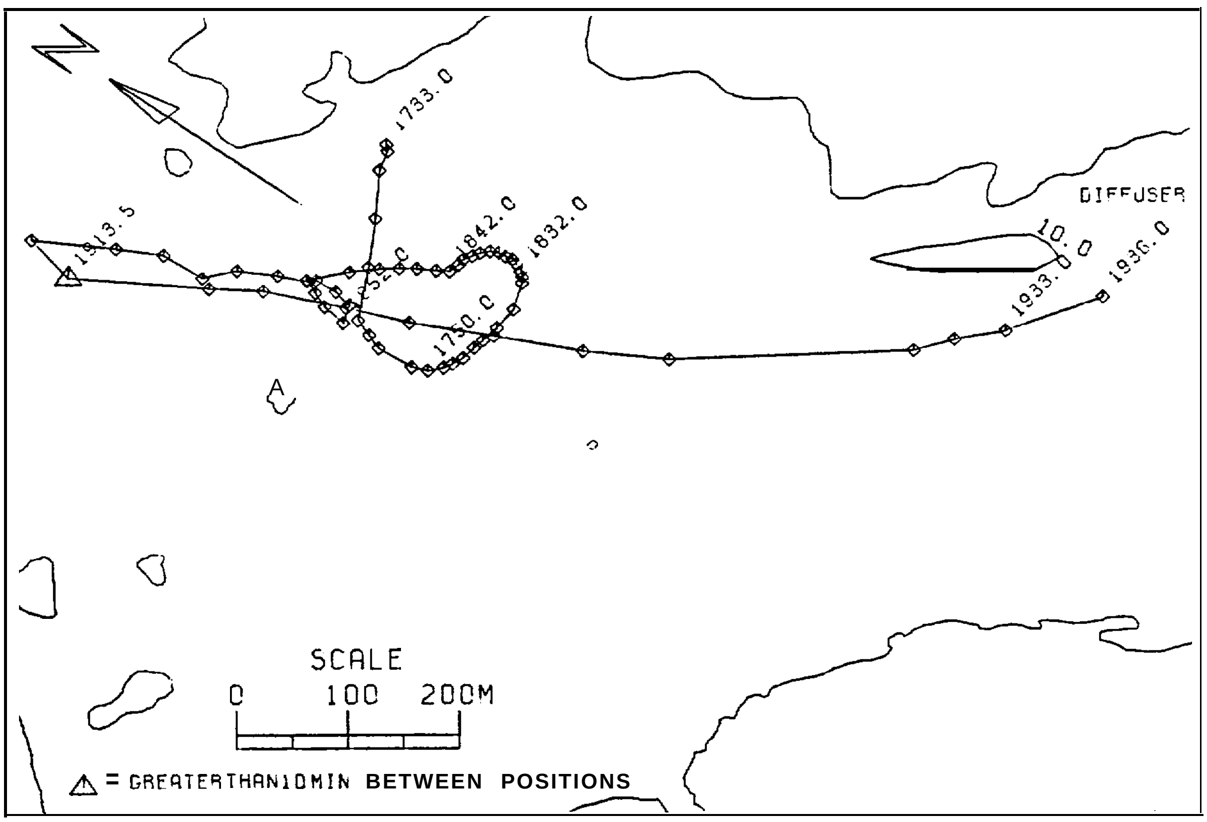
JAKOLOF BAY, FISH 83, TREAT. NO. 3, 7/29/88



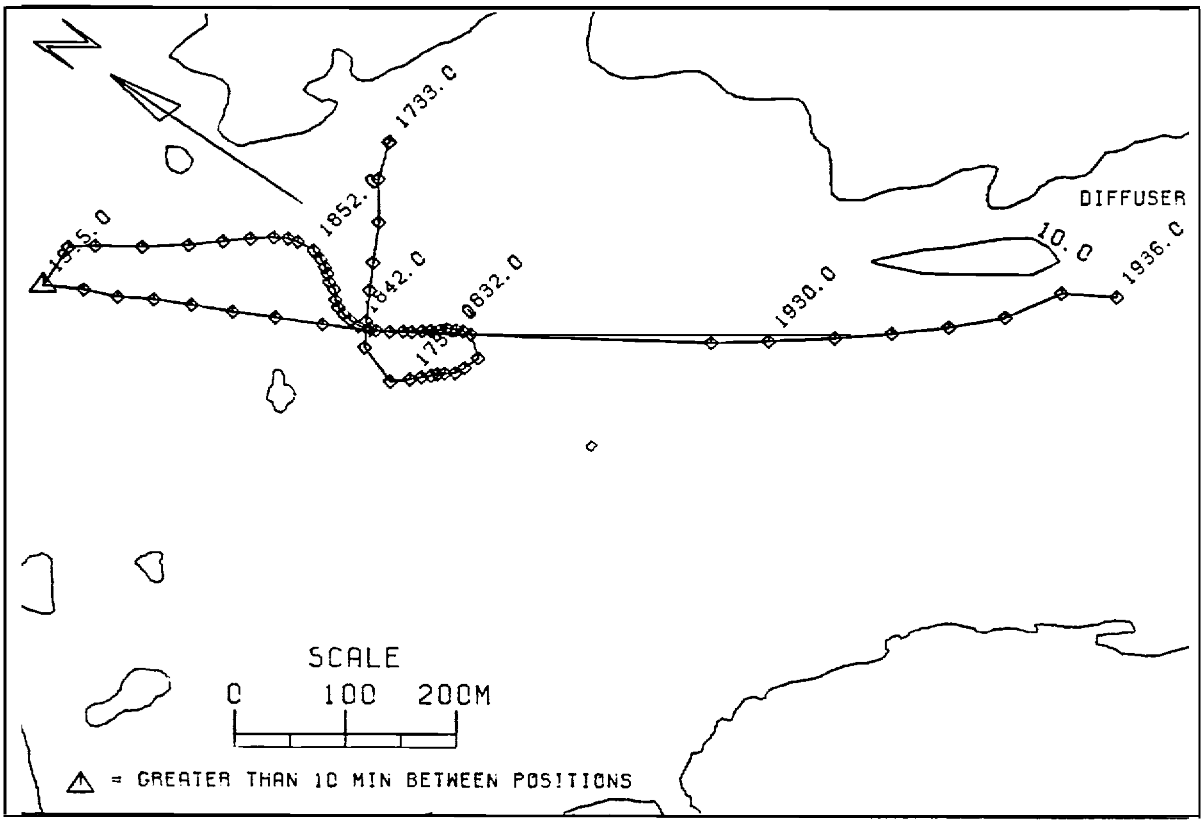
JAKOLOF BAY, FISH 84, TREAT. NO. 3, 7/29/88



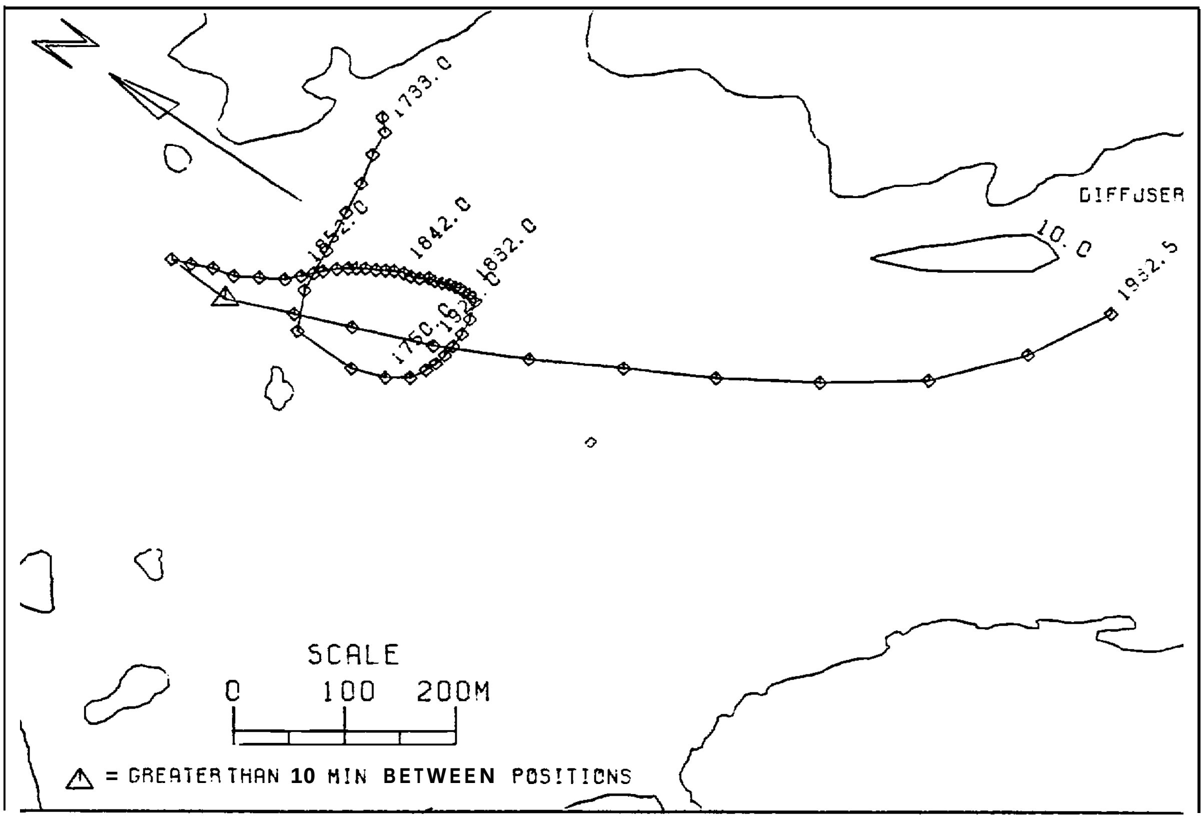
JA KOLOF BA Y, FISH 85, TREAT. NO. 3, 7/29/88



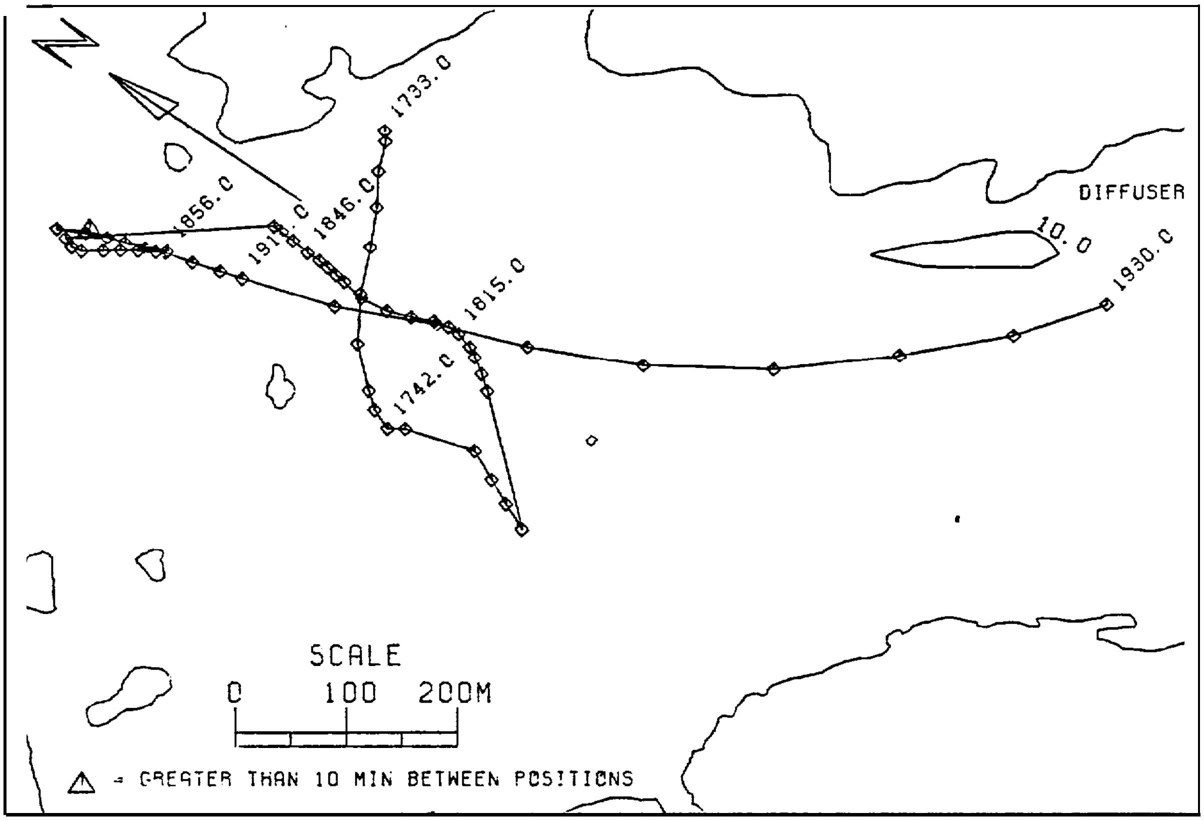
JAKOLOF BAY, FISH 86, TREAT. NO. 3, 7/29/88



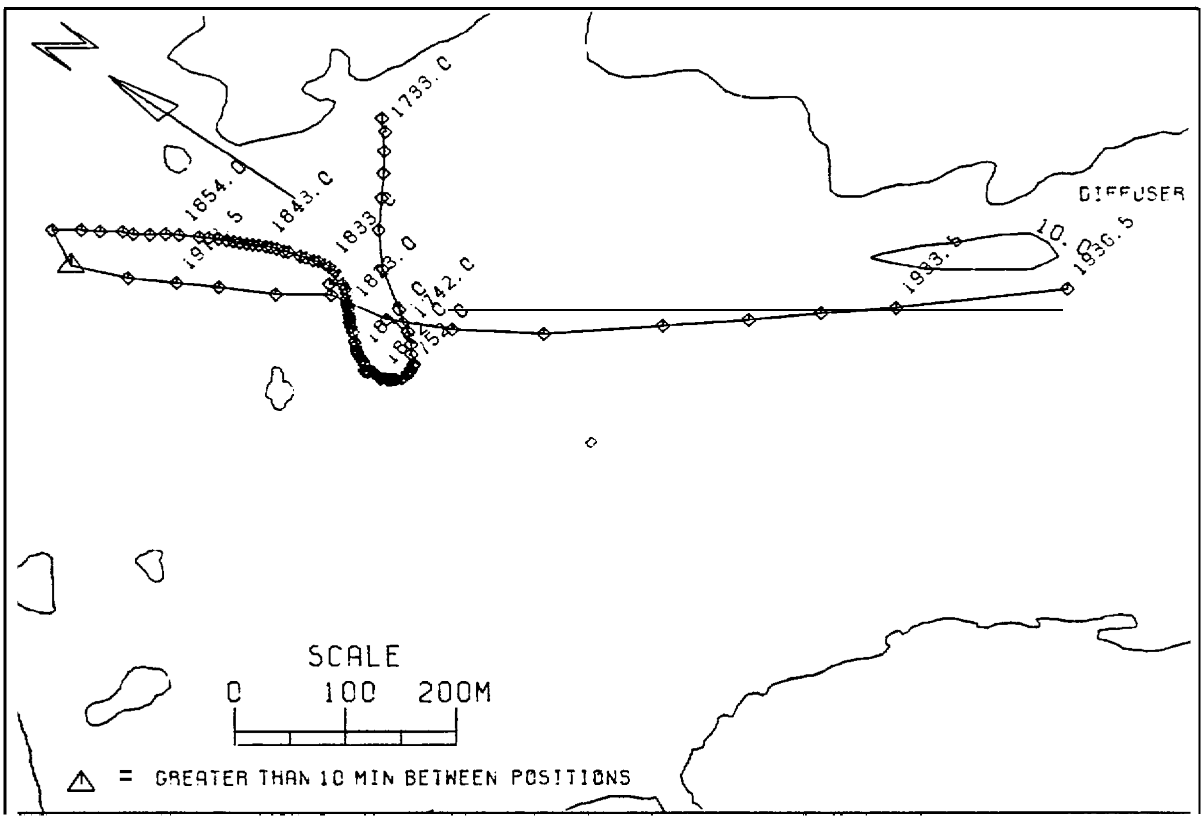
JAKOLOF BAY, FISH 87, TREAT. NO. 3, 7/'29/88



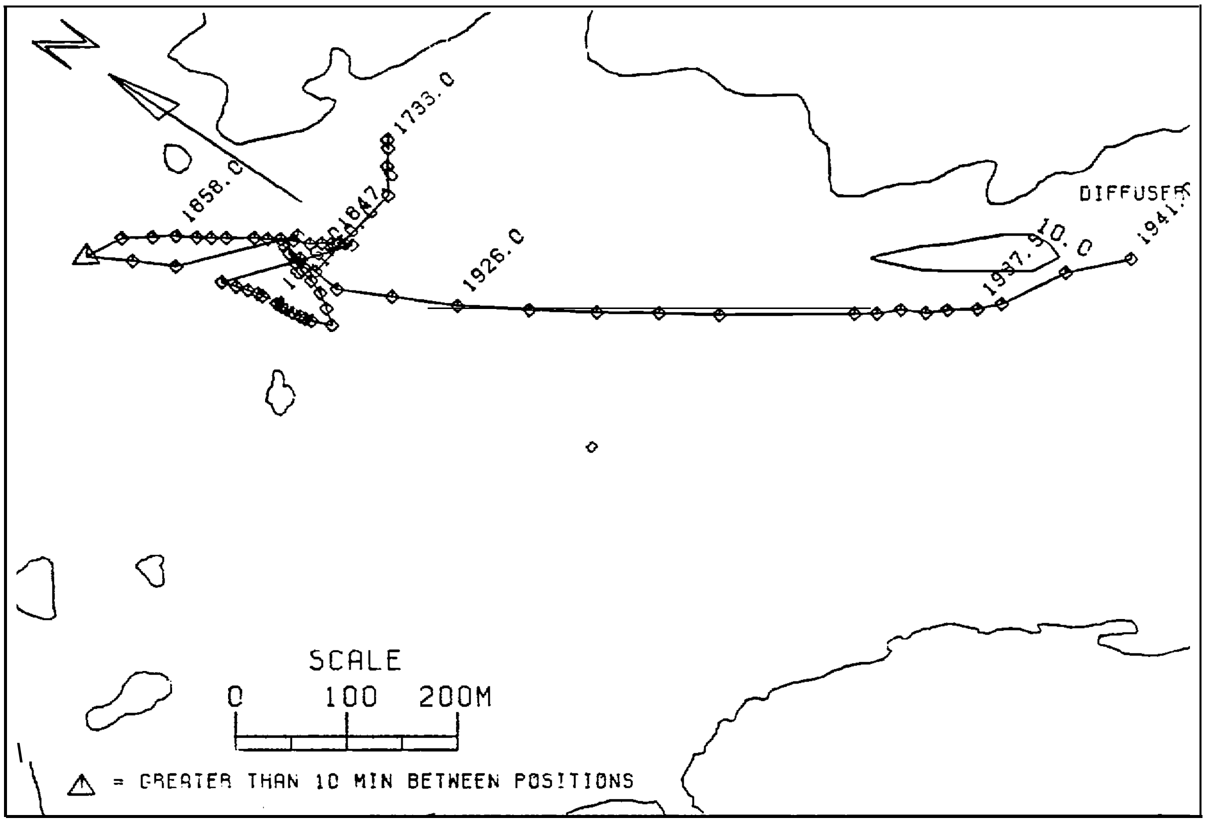
JAKOLOF BAY, FISH 88, TREAT. NO. 3, 7/29/88



JAKOLOF BAY, FISH 89, TREAT. NO. 3, 7/29/88



JAKOLOF BAY, FISH 90, TREAT. NO. 3, 7/29/'88



JAKOLOF BAY, FISH91, TREAT. NO. 3, 7/29/88